Volume 83 Number 8

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

McGraw-Hill Company, Inc.
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JAMES H. MCGRAW, JR., *Vice-Pres.-Treas.*

Chicago, August, 1925

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When You Dance Some One Pays the Fiddler—

You May Think It's Not Yourself, But You Can't Fool the Other Fellow

ONE of my good friends and one time pal who is now engaged in a new line of work that is about 90 per cent engineering and 10 per cent salesmanship, has written me some of his experiences that are interesting, amusing, and pathetic. I'll pass them on to you and you can draw your own conclusions and morals.

One case that he ran into involved a blower installation for a school, that called for a 62½-in. wheel overhung on the shaft, with a pulley center hung for belt drive; so it was specified by the architect and approved by his consulting engineer. It came to light that space limitations along the axis of the shaft were the reason for this stipulation in construction. A suggestion to turn the blower around just 90 deg. so as to use a standard blower construction with overhung pulley and center-hung wheel, saved just about $100 on the installation and 17 per cent of the cost of the standard blower.

In another case a consulting engineer selected for a school, a blower with a 43¾-in wheel to deliver 22,300 cu. ft. of air per min. with an outlet velocity of 2,400 ft. per min., in order to save $128 over the next larger size wheel that would operate quietly with an outlet velocity of 1,800 ft. per min. But the first wheel was installed, to whistle a tune of false economy and poor engineering judgment to school children during the next couple of decades.

In addition to that a slow-speed motor, instead of a standard 1,200-r.p.m motor that could have been used, was selected for the belt drive and "blooey" went the $128 saving and some more along with it. But the written word of the architect in his specifications is law, with automatic enforcement, and the contracting engineer adds 10 per cent on a school job and we pay for it in our taxes, with a grunt perhaps, but that's all.

Here's another case my friend writes me about that is funny. A steel mill engineer wanted to drill ⅞-in. holes in mild steel columns 1½ in. thick, and selected two competing drills to try out. Both were put to work on the job about the same time. One had a high spindle speed and the other had a low spindle speed of about 300 r.p.m. The slow-speed drill went to work and just drilled holes with long, curled-up shavings. The high-speed outfit drilled holes, too, and a little faster at the start; so the lazy, slow-speed drill was laid aside and the other one set to work. Two weeks later the high-speed drill was forced out of commission. The slow-speed drill was again pressed into service and finished the job and is ready for another.

This merely goes to prove that, as has been said many times before in INDUSTRIAL ENGINEER, the life of a piece of equipment depends altogether on the judgment of the man who selects the equipment, the consideration he gives to the work that it will be required to do, the attention and care given to it, and the intelligence displayed by the operator in the use of it.

Well, these are only sketches from the back stage of the interesting drama of engineering life—things the folks out front who pay the price do not see. And yet they believe they are getting their money's worth. and perhaps they do. If we all knew what our mistakes were going to cost us, few of us would ever dare to do anything worth while. It's the lesson of the experience that counts in the end, and I hope you will get a pointer if you need it from what I have passed on to you here from my friend.

Practical Pete

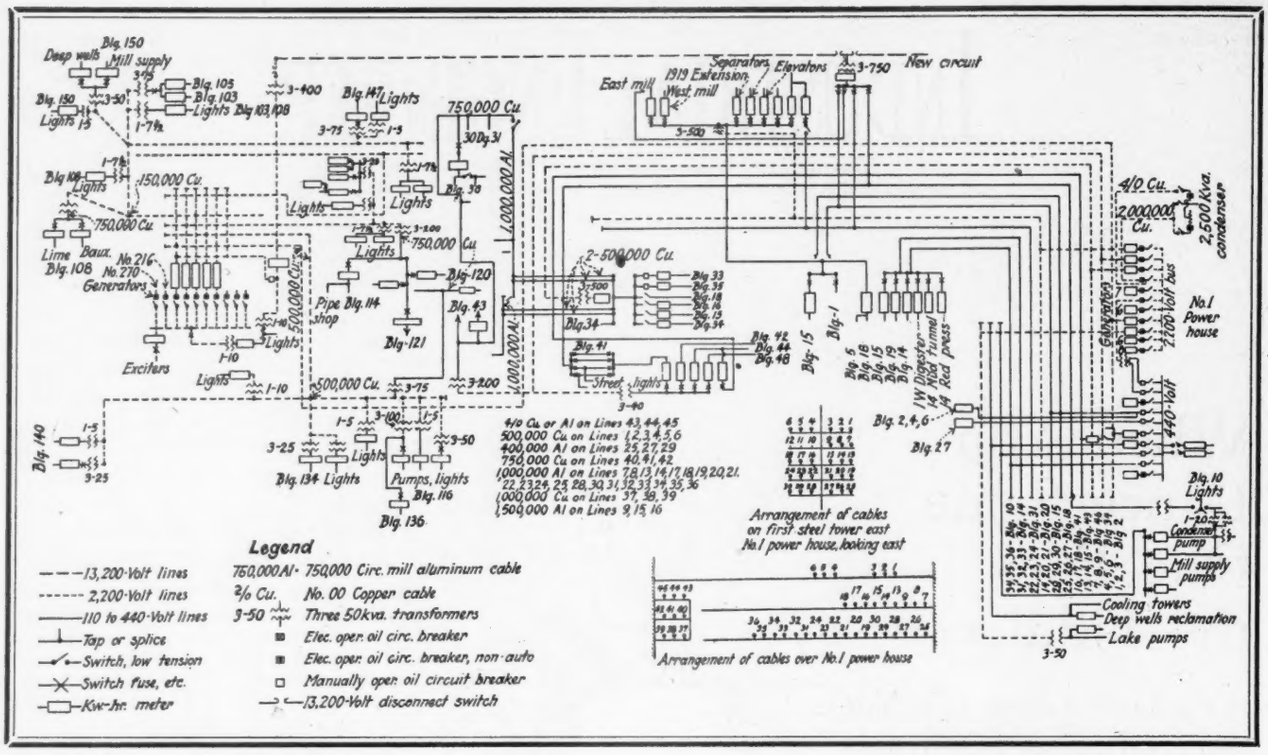

Fig. 1—There is no uncertainty as to where and how the various circuits are run in this plant.

This one-line diagram of the alternating-current circuits is kept up to date by revisions as soon as any changes are completed. Among the various items listed on this diagram are the size, kind and location of conductors, capacity and location of all transformer banks, location of all switches and circuit breakers and what they disconnect, location and number of all watt-hour meters, including the circuits on which the meters measure the power, and much other useful information regarding the system, which should not be left to someone's memory. At the lower center of the diagram is shown the arrangement of the cables as they leave the power house. This is also shown in Fig. 2. The arrangement of the cables on the first steel tower is likewise illustrated.

Considerations That Affect the

Layout of Overhead Electrical Circuits

In Industrial Plant Yards From the Standpoints of Continuity of Service, Safety to Workmen, Cost of Maintenance and General Appearance

By J. ELMER HOUSLEY
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PLANNING the layout of the overhead yard circuits must be given careful consideration if their expansion is to be orderly, safe, and of satisfactory appearance. Naturally, the first consideration is continuity of service, which is followed by safety, provision for future growth, and appearance.

Some plants have all their power distribution and communication circuits underground. This is undoubtedly a very satisfactory place for them; however, the expense is greatly increased. In case the plant covers a large area, and the different parts do not use very large amounts of power, the cost is often prohibitive. In this article we will consider only the overhead circuits, as they are the more widely used of the two systems in industrial works today.

The usual industrial plant yard circuits may be differentiated by two terms: general circuits and local circuits. General circuits usually cover the entire plant area and require the greatest amount of tower or pole space and in consequence require more thought in providing for future expansion. These lines will usually consist of 2,200-volt power circuits, series lighting circuits, telephone circuits, clock, fire alarm, signal and code call circuits. The local circuits are power circuits of low voltage and consequently cover a limited area. These circuits are the 220/110-volt parallel lighting circuits, the 250-volt d.c. power circuits, the 440- and 550-volt power circuits and underground distribution circuits for various services under special conditions which may be peculiar to a given plant.

A one-line diagram of the power circuits in a large plant is shown in Fig. 1. In this diagram the dotted lines represent the 2,200-volt circuits. These are general circuits and extend over the entire plant. The full lines in this diagram represent the 440-volt power circuits. As can be seen the latter lines run only a short distance from the transformers from which they originate and, therefore, they are considered as local circuits.

The main plant power feeders of an industrial plant usually carry 2,200 volts and extend from the power house or substation to vari-

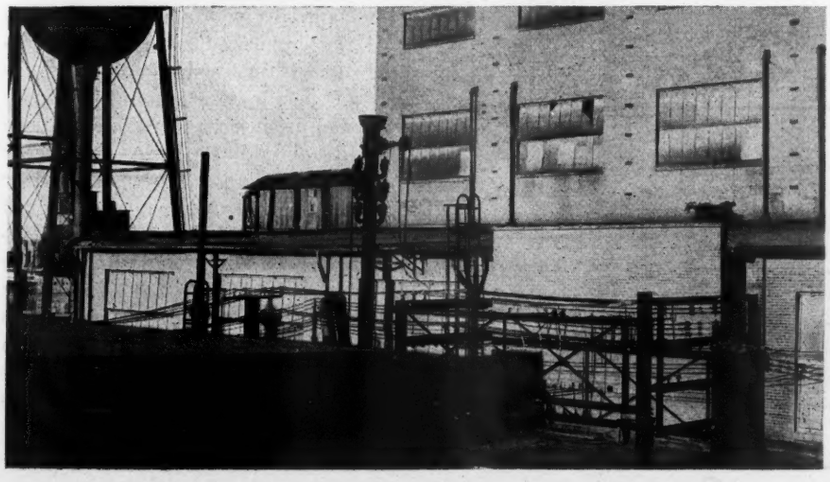
ous load centers in the plant. Steel towers and steel poles are preferred for the main plant lines because of permanence, ease of climbing, appearance and reduced fire hazard. The 2,200-volt circuits are run on the uppermost crossarms, as is indicated in Fig. 5, in order to eliminate the necessity of small lines crossing the 2,200-volt circuits and the resultant danger of falling on them during storms or during erection. The 2,200-volt conductors naturally must be large enough to carry the load intended for them, but should not be smaller than No. 6 hard or medium-hard, drawn copper or No. 4 steel-reinforced aluminum cable. The conductors should be insulated with a triple weather-proof braid when used within the plant boundary. Smaller conductors are likely to break and allow the high-voltage lines to come in contact with the low-voltage circuits. The braid offers no protection against shock at this voltage but it protects the cable during erection and minimizes the damage to the cable from arcing should a yard crane or other object come in contact with the line.

The line insulators are preferably made of porcelain as this material withstands leakage current to a high degree. In almost any plant a certain amount of dust will accumulate on insulators and to prevent insulator breakdowns an insulator rated at not less than 6,600 volts is used on the 2,200-volt circuits when operating under the best conditions. Where various chemicals are present in the air the writer has found it necessary to use an insulator rated at 17,000 volts in order to eliminate service interruptions and burned-off cables. For dead ends, a single disc insulator 7 in. in diameter and having a voltage rating of 10,000 volts has been found to give best results under ordinary conditions. For bad conditions two such units may be used in series.

For outside work, high-tension braided cable in conduit is sometimes used but deterioration is rapid and many service interruptions result. A better method, especially for connecting the 2,200-volt circuits to transformer banks located at the base of the tower or in an adjacent building, is to install a cable pothead at the top of the tower and run lead cable from this pothead to another located at the transformer bank. Iron conduits should be installed for the protection of the cable for a distance of 10 ft. up the tower and where the cable is underground.

ON WHICH crossarms should the various electrical circuits be located, in the overhead distribution system in an industrial plant? What kind of poles, what type of insulators, and what are the minimum sizes of wire that can be used for this work? Should the wires be insulated or bare? Ought the lighting transformers to be located on top of the pole? What is the most satisfactory way of running the service from the pole line to the power transformer bank? In this article Mr. Housley answers these and many other questions on layout of plant yard circuits.

Fig. 2—Arrangement of cables over power house.
As shown in the small diagram at the lower center of Fig. 1, the cables leaving this power house are carried on racks. This arrangement was necessary because the alley between the power house and the adjacent building is only 15 ft. wide and hence it was out of the question to start the steel towers at this point. The cables are carried on these racks for a distance of 200 ft. and then go to the pole line.



Disconnects and oil switches should not be brought within 22 ft. of the ground unless suitably enclosed to prevent accidental contact with live parts. For sectionalizing the service in the plant yard, pole-top, air-break switches of good design may be obtained and where overload protection for branch circuits is desired Schweitzer & Conrad high-tension, chemical fuses may be incorporated with the switch as shown in Fig. 7. Where only overload protection is required and it is unnecessary to switch under load, fused disconnecting switches similar to those shown in Fig. 3 may be used. These disconnects can be opened under no-load conditions only, yet they provide overload protection through the high-tension fuses. For metering such branch circuits outdoor-type current and potential transformers are installed at the top of the tower and the secondary leads run in conduit to a metal meter cabinet conveniently located near the ground. The frame of this cabinet must be grounded.

The 2,200-volt circuits should cross the plant railroad lines as few times as possible in order to prevent accidental contacts with locomotive cranes, as this is a frequent source of accidents. In reaching transformer banks quite a few crossings may be eliminated by using lead cable underground for a short distance. Where crossings must be made the towers should be designed for liberal clearance.

Series Lighting Circuits Should Be Handled as 6,000-Volt Lines

Series lighting circuits find favor for yard lighting in plants of large area and where no elements destructive to insulation are present. In general these circuits should be installed, insulated and handled as if they were 6,000-volt lines, for in case of a grounded circuit near the constant-current transformer a very high potential to ground will exist near the other end of the line. Inasmuch as this circuit is treated as a high-potential circuit it should obviously be installed just under the 2,200-volt lines, as shown in Fig. 5. In order to insure sufficient mechanical strength, the conductors for this circuit should be of solid conductor not smaller than No. 6 hard-drawn copper and should have triple-braid,

weather-proof insulation. Splices may be made with a McIntire sleeve so as to give maximum strength in the joint and to prevent annealing of the wire by soldering.

The insulators should, as was the case with the 2,200-volt lines, be of porcelain and rated at not less than 6,600 volts. The conductor should be securely tied to the insulator with insulated wire not smaller than the line conductor. The series lighting circuit should be attached only to strictly electrical structures and should never be attached to pipe supporting towers or to buildings, for the possibility of high voltage on this circuit constitutes quite a hazard to workmen around such structures and also hampers fire-fighting operations. Where it is essential that lights operating on such a circuit be attached to buildings, a series transformer should be installed on the nearest tower and the secondary run to the light, thereby insulating the lamp from the circuit. Where a pole must be set for a light only, a lamp standard with underground parkway cable may be substituted and will present a more attractive appearance.

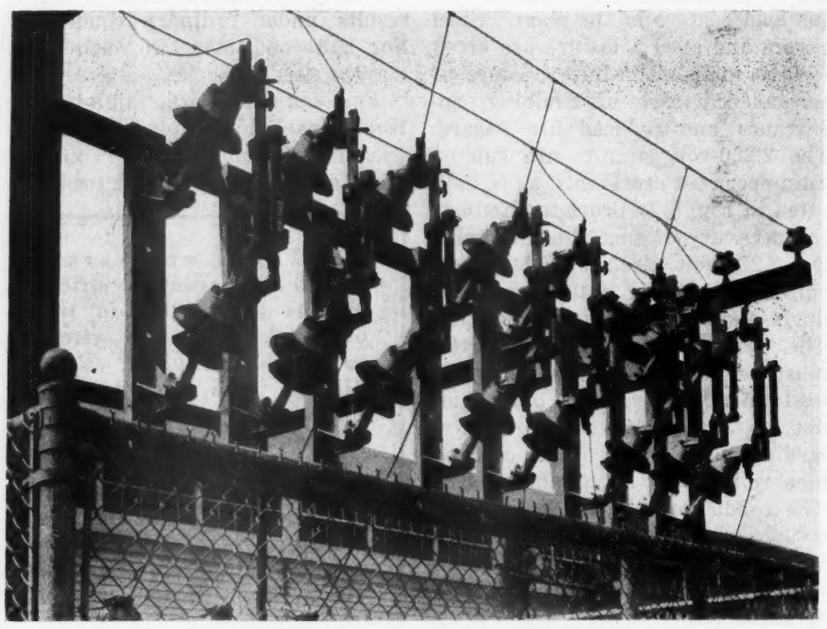


Fig. 3—In some plants line sectionalizing is desired without the use of air-break switches.

This may be accomplished through the use of a fused disconnecting switch. These disconnecting switches must not be opened under load. However, under no-load conditions they may be used to isolate sections of the line. The fuses are of the high-tension, chemical type, made by Schweitzer & Conrad, Inc.

LAYOUT OF CLOCK, FIRE ALARM, SIGNAL AND CODE CALL CIRCUITS

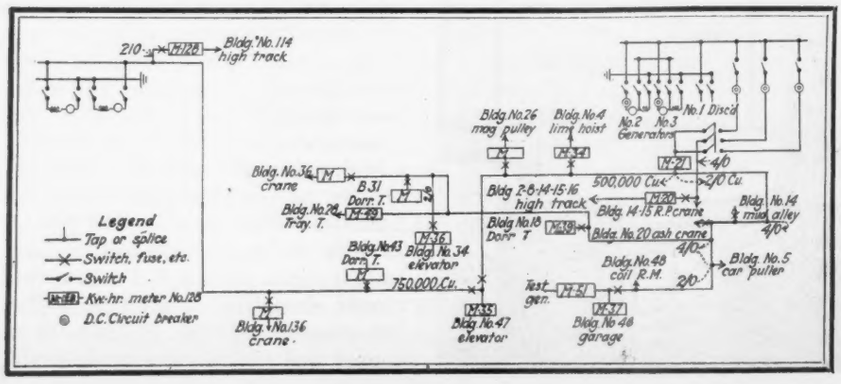
The remaining general circuits to be considered are the clock, fire alarm, signal code call and telephone circuits.

The clock-regulating circuit as furnished by the telegraph companies consists of a single wire over which impulses at 250 volts are sent once an hour. These impulses regulate or set the clocks, which are arranged in multiple. The winding of the clocks is usually accomplished by a dry cell in the clock case. Many plants use a local master clock, however, which sends out an impulse once per minute and advances the clock hand by that interval, the source of energy being ordinarily taken from the lighting service or from storage batteries.

The code call circuit is usually operated from the telephone operator's desk by some automatic, code-sounding device. This sends out 110-volt impulses to the vibrating horns, bells and whistles in the plant, which are connected in multiple. Owing to the small amount of energy required by the horns the lines may be as much as a mile long and operate several horns satisfactorily at this low voltage.

Fig. 4—This shows the direct-current circuits of the plant mentioned in Fig. 1.

These circuits are carried on the same poles as those shown in Fig. 1. The reason for showing them in a separate diagram is to make the diagram more simple and easy to follow in tracing the circuits.



The various other signal circuits will seldom require over 110 volts. The fire alarm circuits are usually of the closed-circuit type with a break-glass or pull-down box for giving the coded interruption to the closed circuit which is energized by a number of primary battery cells. The circuit may be energized by 250 volts d.c. or lower, through a resistor in order to give the required value of current for operating the relays. Quite often the alarm is sounded throughout the plant by single-stroke gongs, operated in series or in multiple on 250 volts d.c. These bells are located at strategic points in the yard and in all buildings.

The nature of the above circuits would indicate that they should be installed on the crossarms lowest on the tower, but above the smaller and mechanically weaker telephone wires, as is shown in Fig. 5. These circuits should never cross over 2,200-volt circuits and should be at least 4 ft. below such circuits because these signal circuits enter buildings and the connected apparatus is frequently within touch of a large number of people who should be safeguarded as much as possible. These circuits should use a line conductor not smaller than solid No. 8 hard or medium-hard drawn copper, covered with triple-braid, weather-proof insulation. The line insulators may be of glass, single-petticoat type. The conductors are tied to the insulators with insulated wire not smaller than the line conductor. Where these circuits leave the tower or pole lines and run inside or outside of buildings, they should be enclosed in con-

duit to prevent mechanical damage or electrical crosses with other wires.

The telephone circuits may be called the arteries of the plant and deserve careful consideration to prevent accidental interruption of service and to insure safety. To the writer the bare telephone line has never appeared to have any justification for use within the industrial plant yard. It is especially liable to accidental crosses with other circuits, it is easily broken, and when a break occurs it usually wraps about other circuits and shorts them out; also this method takes up a large amount of expensive pole and crossarm space. Where five or less telephone circuits must be run in the open for less than 300 ft., No. 17 s.c.c. rubber-covered, weatherproof braid, twisted-pair telephone wire may be profitably used. For longer distances or where a larger number of lines are required, service and safety are promoted by the use of lead-covered telephone cable. A sufficient number of extra pairs should be provided for the probable increase in traffic, which inevitably occurs.

In order to safeguard the delicate telephone equipment and protect the telephone user, a line protector consisting of a lightning arrester and fuses should be installed on each circuit where it enters a building.

The telephone lines inside of the building usually use No. 19 tinned-copper, twisted-pair conductor with rubber insulation and a single glazed braid.

Lead-covered telephone cable, where installed on the plant steel tower lines, requires some modifications of suspension practice to secure safety. In making a number of investigations of cable troubles ascribed to lightning the writer found small holes burned in the cable under the supporting clips, often as many as 17 holes would be found in a length between three towers. While being familiar with the vagaries of lightning the casual explanation did not appear logical and so the insulators of the 2,200-volt lines on the adjacent towers were given a minute examination. In three cases there were found defective insulators which had a crack extending either from the top of the saddle or from the tie wire groove to the iron pin. During a storm a heavy current would pass from the cable through the cracked insulator and thence to the pin through the tower to the messenger cable. The current would go both ways to the adjacent towers. Inasmuch as the messenger wire was in parallel with the lead sheath, current would enter the lead sheath through the supporting rings, thereby burning small holes in the lead sheath. In one instance the switchboard operator observed a heavy surge on the 2,200-volt feeder on which the trouble occurred. Although all of the towers were well grounded, the R1 drop in the steel tower forced the current along the messenger and lead cable to the adjacent towers.

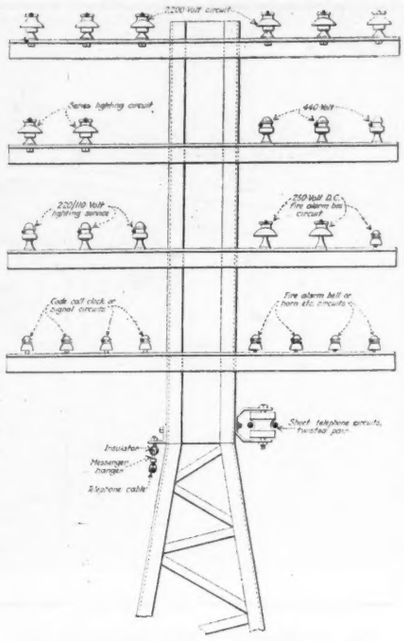


Fig. 5—Preferred crossarm locations for the different circuits of an industrial plant distribution system.

The high-voltage lines are placed on the uppermost crossarms. The lowest crossarms carry the various signal circuits, which are of low voltage. The alternating-current low potential and the direct-current low potential circuits are carried on the crossarms in between. Only four crossarms are shown here, but others can, of course, be added where needed.

Two methods have been used to eliminate this trouble, one being to mount a treated maple block on the tower and bolt the messenger clamp to it; the other is to put a horizontal angle on the tower and suspend the messenger clamp by a guy insulator from the angle extension, as shown in Fig. 5. Such isolation of the messenger and cable has been effective in eliminating these troubles. The messenger and cable are grounded at only one point, that being where they enter the building housing the exchange.

All telephone lines entering the plant cable from outside of the plant should be provided with an arrester and heat coils, as considerable damage may be caused by "sneak" currents burning open the lines in the cable.

Local Circuits Should Not Be Run on the Outside of Buildings

The motor circuits are usually of 440 and 550 volts a.c. and 250 volts d.c. Since they are local in character they seldom occupy much space on the yard towers. Where the low-

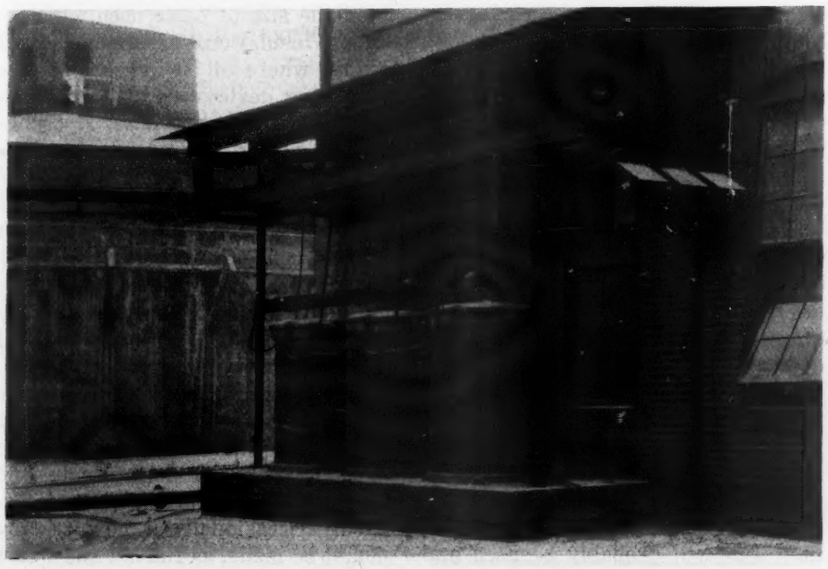


Fig. 6—Lead-sheath cable is used for connecting the transformer bank to the overhead line.

A cable pothead is installed at the top of the pole. The cable is run down the pole and underground to the transformer bank. For protection, the cable is run through conduit underground and for 10 ft. up the pole and at the transformer bank. The illustration shows the cable and conduit coming out of the ground at the bank of transformers. The cable terminates in a pothead which is located behind the lightning arrester at the right center of the illustration.

tension circuits supply two or three buildings adjacent to a step-down transformer bank they may occupy the space on the tower below the 2,200-volt circuits and above the signal circuits, as is shown in Fig. 5. The design of these circuits should be such that they will not be run along the outside of the buildings being served, as they detract from the appearance of the building and in some cases may pull the framework of the building seriously out of line. To the writer's knowledge this has happened, and it really is very poor practice unless the design of the building is positively known to be able to stand the strain of the wires under all conditions. There is also considerable danger in connection with firefighting operations around the building, if power circuits are run on the outside.

The service entrance may be by means of cables stretched from the tower line to the building with a conduit entrance into the building. Main switches should be provided inside of the building, so as to make it possible to shut off power to the various parts of the building. The most common fault of these service connections is that the cables are not spaced far enough apart and insufficient clearance from grounded structures is provided. Under such conditions short-circuits are easily established and changes in sag and alignment cause grounded circuits. Where space on the tower is crowded it may be advisable to use lead-covered, three-conductor power cables with potheads and run such circuits down the tower and underground into the buildings.

The installation of 2,200-volt lighting transformers on the yard towers always presents a problem both in securing clearance for the primary leads and safety to the repairman working on a case of trouble. A very satisfactory solution is to eliminate the 2,200-volt transformer on the pole or tower and install a 440/220/110-volt transformer at each 2,200/440-volt transformer bank. The lighting service may be supplied to the local load center from this point. The slightly increased losses are compensated for by the increased safety to linemen and greater security from lightning. The location of the 220/110-volt lighting circuit on the crossarms is shown in Fig. 5. Wherever transformers of any type are installed on the 2,200-volt system, the concensus of opinion favors the installation of lightning arresters.

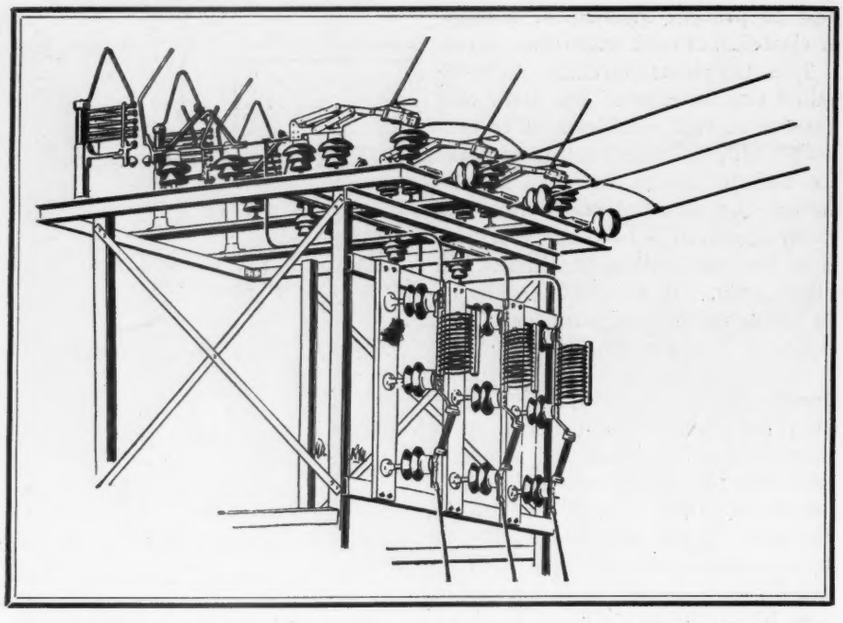


Fig. 7—Here is a typical layout for pole-top, air-break switches including overload protection.
The overload protection is obtained through the use of Schweitzer and Conrad high-tension chemical fuses. As may be seen, lightning arresters and choke coils are also provided for in this layout.

Quite frequently the industrial plant fails to observe the code ruling that the low-tension secondaries (110-220 volts) of transformers must be grounded, either on the neutral of the three-wire system or on one line wire of the 110-volt service. This neglect presents a certain hazard to men using portable electric drills, extension lamps, etc., and more serious results may occur in case of a breakdown of the insulation between the 2,200-volt primary winding and the secondary winding of a transformer.

Where the series lighting circuit is not practicable because of insulation troubles the yard lighting system may be operated in small groups from the 220/110-volt service just described. A satisfactory method is to mount a switch under each light and use an enclosed cutout between the main feed circuit on the tower line and the lamp. A weatherproof condulet push-type switch may be used in preference to a rotary switch, as the rotary switch buttons are often removed and lost by mischievous persons.

The 250-volt d.c. power circuit is frequently used for local service, principally for power house, machine shop and other variable-speed drives and traction service. Where the plant is large, several motor-generator sets will probably be used and relatively short feed lines employed. Considerable study should be devoted to the problem of eliminating drives requiring such special service at scattered points in the plant. These circuits should occupy about the same position on the poles or towers as the local 440-volt and the lighting circuits, as is shown in Fig. 5.

Considerable difficulty has been experienced from lightning disturbances on the 250-volt d.c. circuits and provision should be made for the use of lightning arresters at all building entrances. The only explanation offered by the writer's experience is that the a.c. circuits were always equipped with lightning arresters as a matter of course, while the d.c. circuits were not, until equipment losses indicated the necessity of this protection.

A plan of the distribution system is invaluable for the large as well as the small plant. On it should be noted the size of cable used, character of insulation, arrangement on towers, where oil switches and disconnecting devices are located, location of meters, capacities of transformers, and main secondary subdivision of lines. These constitute some of the important information easily forgotten unless noted on some form of drawing. Fig. 1 is a one-line diagram of the 2,200-volt and 440-volt lines in a large plant and on it is incorporated all of the information just mentioned. Fig. 4 is a similar diagram for the 250-volt d.c. system. Additions and revisions to these drawings should be made at regular intervals and new blueprints issued to those interested. Occasionally a new tracing should be made, as the old one wears out under many erasures.

Fig. 1—A properly-designed lighting system makes all of the difference between a dark and gloomy shop and one that is cheerful looking and easy to work in.

The illustration at the left shows how the punch press department in one plant looked when illuminated by the original lighting system, which gave an average illumination of 0.7 foot-candles. As will be noted, drop lights had to be used at some of the machines. The other view shows the same department lighted by the new installation of 200-watt lamps in R L M dome reflectors. The new system gives an illumination of about 13.5 foot-candles.

Practical Pointers on

Better Illumination in Industrial Plants

Together With a Discussion of Results Obtained Therefrom in the Way of Increased Production and Reduced Accident Hazards

By ROY A. PALMER

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ARTIFICIAL light has become such an efficient and dependable asset in our modern life that we rarely stop to consider how much it contributes to our welfare and happiness. In almost every important activity in which we are engaged, artificial light plays some part and in the large majority of cases the role which it plays is almost indispensable.

Notwithstanding the rapid progress which artificial lighting has experienced and the completeness with which we have absorbed it into our daily lives, the lighting of this country as a whole has not reached a high standard. It is true that America can be termed the best-lighted country in the world, for other countries are far below even our present standard, but with the benefits which better lighting brings at a comparatively low cost there are possibilities for even greater use of light with profit to the user and worth while advantages all around.

There are, no doubt, many plant executives who feel that the lighting systems in their factories are fully adequate. However, the lighting systems which were satisfactory four or five years ago may be far below the standard of what is considered good lighting today. Changes in the structural features of the building have, perhaps, altered the existing arrangement of outlets, so that the illumination is now insufficient; substitution of improper lamps for those burned out or broken throughout the period of a few years may have introduced lighting conditions that are condemned by modern standards; or the character of the work now performed in the factory may demand a higher standard of illumination. These are only a few of the factors which require checking over to ascertain whether or not the factory is obtaining full benefit of the advantages which better lighting brings. In not a few cases have the lighting systems never measured up to good lighting requirements, and in those factories the matter of revamping the existing installation should be given the most serious consideration.

It is obvious that by the amount of light available we are accordingly enabled to see. During the hours of darkness we can only distinguish outlines of objects, but in the sunlight it is easy to perceive small details. That illustrates the wide range of intensity of light to which our eyes can adapt themselves. If a

WE ARE SO USED to doing a large part of our work by artificial illumination that it is easy to take such lighting for granted, without much thought as to whether the amount of light furnished, or the type of equipment used, are suited to the working conditions. Oftentimes, too, there is a failure to realize that a level of illumination that is entirely suitable for one class of work or conditions may be altogether inadequate for another kind of work or set of conditions. In this article Mr. Palmer points out the dollars-and-cents value of good lighting from the standpoints of production, decreased accident hazards and general improvement in working conditions. Other phases of this subject will be presented in articles which will appear in succeeding issues of Industrial Engineer.

factory were operated only during the hours of darkness and no artificial light were provided, the output of that factory would be very small indeed. If only a little light were supplied, the output would be a little greater. The production would be almost entirely dependent upon the illumination supplied. While there are other factors which affect production, it can be readily appreciated how intimately good lighting is linked with production when we compare utter darkness and only a very small amount of light. But the efficiency of the worker is not at a maximum when the illumination is merely sufficient for good vision. The worker can see sufficiently well to work slowly under one foot-candle of illumination. Yet that worker is laboring under a partial blindfold. With five foot-candles of illumination that blindfold will be very considerably removed. At ten foot-candles the worker's visual powers have further increased. The finer the grade of work and the greater the demands upon the vision, the more light will be required.

The percentage of gain in visual power of the eyes is illustrated in the chart shown in Fig. 2. The curves show the results of tests conducted by Drs. Feree and Rand at Bryn Mawr University. In their experiments they found that as more light was supplied, the visual powers of a normal eye increased very considerably. With sub-normal eyes, however, it was found that their visual powers increased even more rapidly than in the case of normal eyes, when the amount of light was increased.

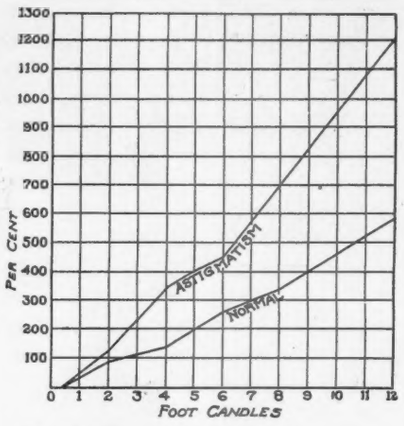


Fig. 2—How visual power increases with increase in the intensity of illumination.

This chart is based on the results of experiments conducted by Drs. Feree and Rand of Bryn Mawr University. It will be noted that the increase of vision with the increase of illumination is materially greater in the case of persons with defective eyesight than with those of normal vision.

Good Factory Lighting Improves Working Conditions

While the factory management is naturally most interested in those items which affect increased production or lower unit costs, more favorable working conditions are also important, for it is generally appreciated that the working conditions are reflected in the rate and quality of production. Good lighting is one of the greatest contributors to better working conditions. Inadequate lighting causes an atmosphere of gloom in the room. It is only fair to the workman that he be given a cheerful place in which to work, for it must be remembered that he spends at least one-third of his time at the factory. It is essential that the worker be provided with good tools and up-to-date machinery to turn out the best work. It is likewise essential that good lighting be provided so that his visual powers will enable him to use the tools and machinery to the best advantage.

There are many plants where the illumination is not what it should be, merely because of neglect of the lighting system. Changes may have been made in the factory at various times of the year, which perhaps cut off the light from some lighting units or in some other way rendered the existing lighting system ineffective. Perhaps more exacting demands require closer visual application and the level of illumination should have been raised to prevent unnecessary eye strain. Many other reasons could be cited why attention should have been given to the lighting system in order to assure adequate illumination. In view of the benefits which better lighting brings to the employees and the factory owners, it is important that every plant executive give due consideration to the lighting of his plant.

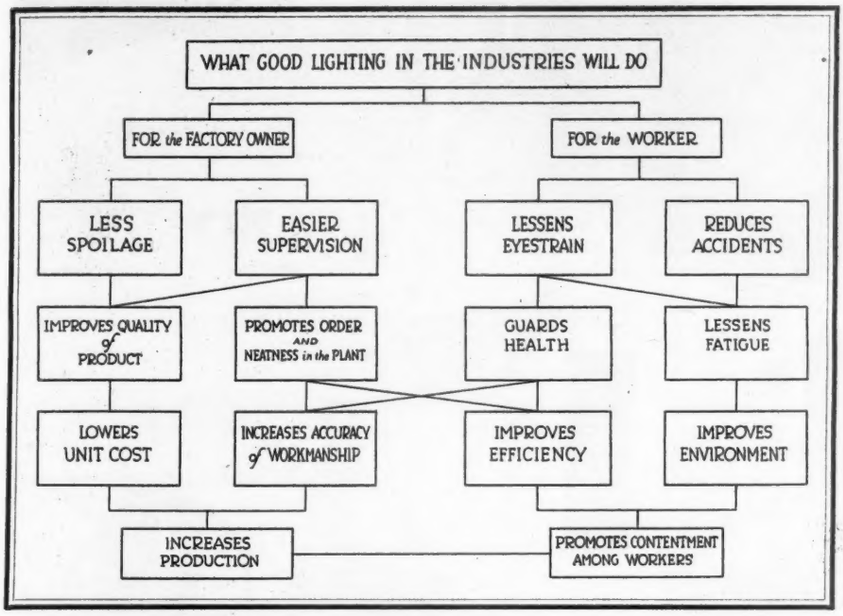
It is not an unreasonable claim that better lighting reduces accidents. There are many cases in which improper and inadequate illumination can be blamed for accidents and perhaps many more cases where the illumination may not be a direct, but is a contributing cause. Because of the fact that it is sometimes extremely difficult to determine the exact cause for some accidents, definite figures which show the direct relationship between accidents and lighting are not readily available. However, one does not need to stretch the imagination to realize the possibility of accident in a poorly lighted factory. Stairways, objects hidden by dark shadows, swiftly moving machine parts are only a few of the sources of accident when insufficient or improper light prevents the sense of sight from acting quickly enough to avoid danger. Examples of these conditions are shown at the left in Figs. 1 and 3.

In direct contrast to light and accidents, definite and tangible figures are available regarding the effect of better lighting on production. Many tests which show the important bearing of light upon the output of the plant have been made in various industries. Illumination production tests have been made in industrial plants covering a wide variety of operations. The results of nine such tests are shown in the accompanying table.

One of the most interesting of these tests was that conducted by the Office of Industrial Hygiene of the United States Public Health Service. In the belief that the work of letter sorting could be expedited by supplying more light upon the

Results of Some Tests That Show the Practical Value of Good Lighting

Kind of Work	Average Foot Candles with Old System	Average Foot Candles with New System	Per Cent Increase in Production, New System	Additional Lighting Cost in Per Cent of Payroll
Pulley finishing	0.2	4.8	35	5
Soft metal bearings	4.6	12.7	15	1.2
Heavy steel machine	3.0	11.5	10	1.2
Carburetor assembly	2.1	12.3	12	0.9
Manufacture of electric, gas and sad irons	0.7 (4.0 at tool point)	13.5	12.2	2.5
Semi-automatic buffing brass shell sockets	3.8	11.4	8.5	1.86
Manufacture of piston rings	1.2	18.0	25.8	2.
Letter separating	3.6	8.0	4.4	0.6
Inspecting roller bearing parts	5.0	20.0	12.5	2.4
Average	2.69	12.47	15.04	1.96



work, this test was undertaken. The illumination was raised from 3.6 foot-candles to 8 foot-candles and it was found that the speed in the work of letter sorting was increased 4.4 per cent. Since the work in other departments of the post office is mainly visual, it is reasonable to believe that a similar increase would obtain if the level of illumination were raised. It was estimated that a saving of $109,000 could be made in the post office where the test was conducted, should the same increase of speed apply throughout the entire office. The economy of better lighting is even more striking when the fact is taken into consideration that this saving is three times the increased cost of illumination.

Another interesting test was conducted at the Timken Roller Bearing Co. plant at Columbus, Ohio. Several weeks were devoted to this test and the high and low levels of illumination alternated weekly. The test was conducted in the inspection department where thousands of bearings are inspected. This process requires fairly close visual application. The effect of better lighting was brought out in a striking manner by the production figures under the low and high levels of illumination. When the high level of illumination was provided, the production increased; when the illumination was cut down, the production decreased. With each change in the level of illumination the production output responded accordingly. The illumination in this plant was originally five foot-candles, which is not so low as is found in many plants. The new lighting system installed for the test provided 20 foot-candles. While the five foot-candles of illumination were sufficient for fairly good vision, the new installation helped the speed of vision and produced a stimulating atmosphere in the plant so that production was increased 12.5 per cent.

The average increase in production for the nine tests, as shown in the table, is 15.04 per cent, with an average additional lighting cost of 1.96 per cent of the payroll. Increases in production as high as 25.8 and even 35 per cent were obtained in some plants.

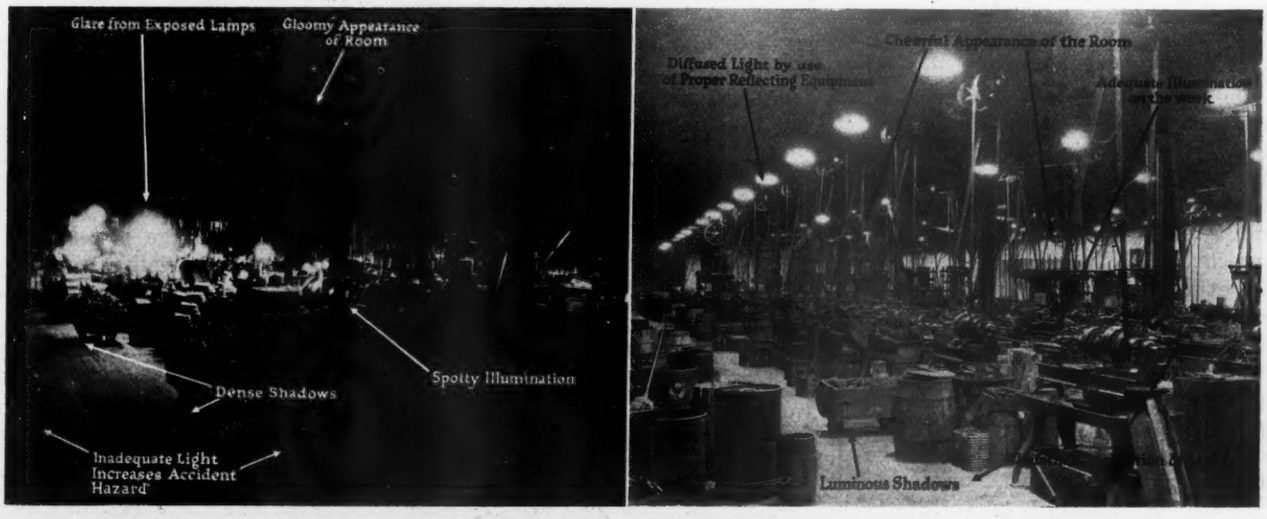
In each one of these tests every effort was made to balance out all factors that could affect production figures, except lighting. Furthermore the tests were conducted over a period sufficiently long to obtain average conditions and results.

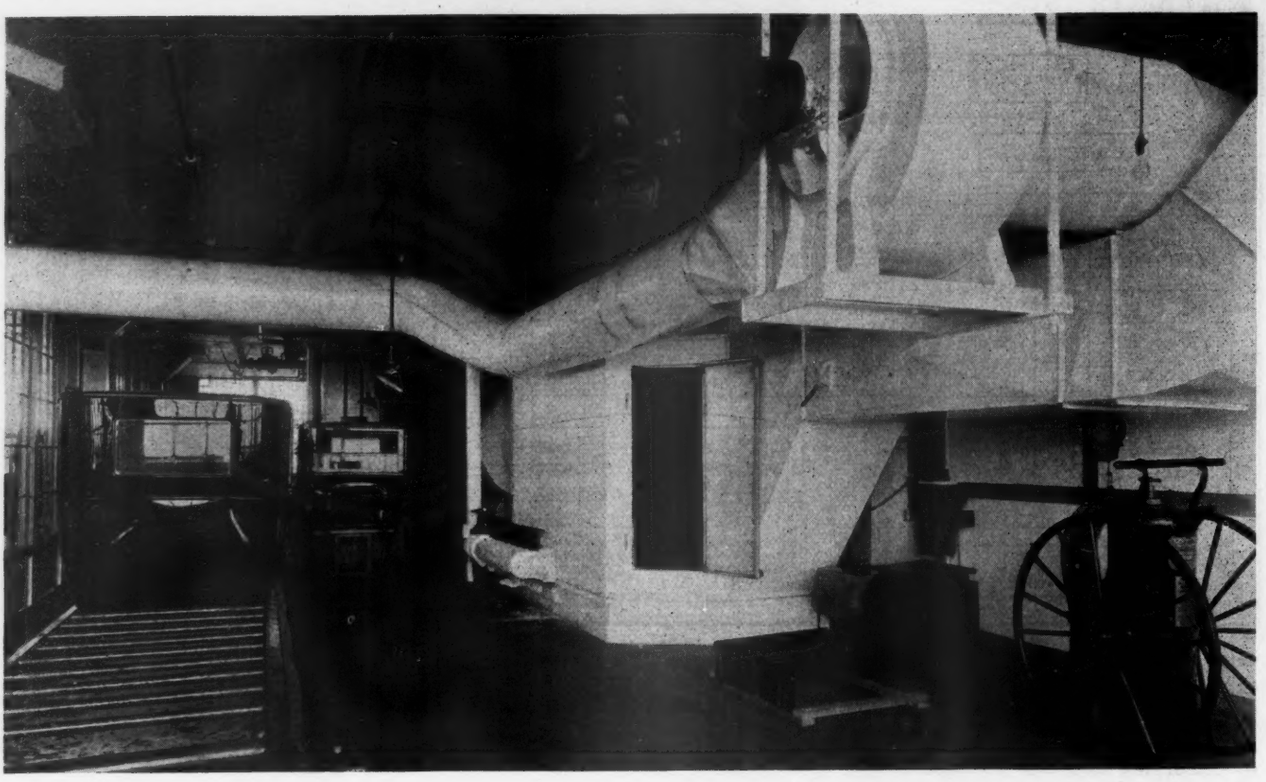
If it were only possible for every factory manager to view his plant as it would appear if illuminated by an up-to-date lighting system, there would be no need to try to convince him of the benefits of better lighting by means of statistics. The immense contrast in the appearance of the rooms, the ease with which small details may be seen, and the stimulating effect of an abundance of light would be sufficient for him to realize that more and better work could be done under such conditions. It is somewhat difficult to appreciate

(*Please turn to page 402*)

Fig. 3—These illustrations show some of the points of difference between poor and good lighting systems.

As will be seen in the photograph at left, the use of localized lighting at some of the machines, results in a very low level of illumination (0.2 foot-candle) throughout the remainder of the room. In particular, the very poor lighting of the floor around the machines and in corners constitutes a serious accident hazard. In contrast, the view at right shows how all of these objectionable features can be eliminated by a lighting system that is properly designed and adequate for the service. In this illustration, the illumination is about nine foot-candles.


Glare from Exposed Lamps
Gloomy Appearance of Room
Dense Shadows
Spotty Illumination
Inadequate Light Increases Accident Hazard
Cheerful Appearance of the Room
Diffused Light by use of Proper Reflecting Equipment
Luminous Shadows



Here a number of sectional filter units are used to purify the air used in the drying room in an automobile plant. The sectional units may be seen through the open door leading into the heater room.

Some Things It Pays To Know About

Separating Dust from Air in Industrial Plants

So That Clean Air May Be Used in Industrial Processes, for Heating and Ventilating, or May Be Discharged into the Atmosphere

By CHARLES L. HUBBARD

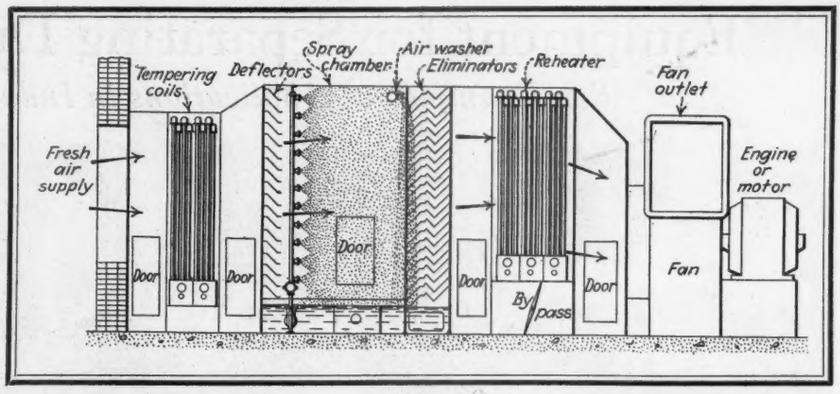
Mechanical Engineer, Boston, Mass.

AFTER dust has been removed from the atmosphere or collected from exposed surfaces upon which it has settled, as was described in the preceding article entitled, "Removing Dust Produced in Industrial Plants," in the July issue of INDUSTRIAL ENGINEER, it must be separated from the air which carries it before the air can be exhausted into the plant or the atmosphere. In other cases the atmospheric dust in incoming air must be removed before the air can be used in and around the processes performed within the plant. Some of the methods of doing this will be taken up in this article.

Dust-laden air is cleaned by passing it through some type of separator. In general, these separators are either of the "wet" or "dry" types, although in some cases both types are used together. Generally, if the practically dust-free air is to be discharged into the open some form of dry-type separator is used. It is seldom necessary to have the discharged air absolutely dust free, as it usually can contain some fine particles which become diffused in the atmosphere.

ATMOSPHERIC DUST must be removed from incoming air before it can be used in many processes. Also, the dust-laden air, which is taken up in industrial sweeping operations and other methods of dust removal, as was described in the July issue, must be cleaned before it can be discharged into the atmosphere. Some of the various types of equipment used for removing dust from air are taken up in this article.

When the dust and dirt are collected by pneumatic sweeping equipment it is practically always necessary to remove them from the air before passing through the exhauster, as was explained in the previous article. This is because most types of pneumatic sweeping equipment use either rotary or multistage turbine exhausters which do not pass solid material. Where a quantity of solid materials is picked up in a sweeping process, such as when sweeping floors in boiler rooms and in grain elevators, the air is often passed first through screens or through a centrifugal separator which removes all large pieces and then through a bag or other similar filter to remove the dust. For ordinary sweeping work so few large, solid particles are gathered up that a separate centrifugal separator is seldom necessary. A separator which employs the centrifugal principle for the removal of the coarser particles and a filter bag for removing the



This diagram shows an air washing unit in connection with a heating system.

Here the incoming air passes through a spray chamber filled with mist and then through a heavier curtain of water which drives the particles of dust, already moistened by the mist, down into the settling chamber. Moisture is largely removed in the eliminator.

finer dust is shown in a sketch on page 369.

With dry separators, whether of the centrifugal, screen or bag type, the dirt accumulates in a closed chamber at the bottom of the separator and must be removed at frequent intervals for burning or other disposal. In some cases the dust chambers are emptied automatically, as was shown in the illustration at the bottom of page 322 in the July issue. Here, as the dust accumulates, the dust pan automatically trips and empties itself without interfering with the operation of the separator.

In some cases screw conveyors or other devices in continuous operation are used to remove the dust deposited in the bottom of filter chambers. In many cases, however, particularly where a small amount of material is recovered from the air, hand valves or gates in the bottom of the settling chamber are sufficient.

The cleaning of the filter cloths is a still more important item. In some cases these bags are cleaned regularly by shaking or rapping. This is sometimes done by a revolving shaft and a cam action which regularly jars the material loose from the bag. In other cases the equipment is stopped at intervals and the direction of the air current reversed, which causes the material to drop loose from the inside of the bag. With filter equipment where it is necessary to reverse the air current to clean the bags, an installation is usually made up of several units so that one unit can be cut out at a time to be cleaned. The length of time between cleaning depends, of course, upon the material handled and the quantity of dust removed.

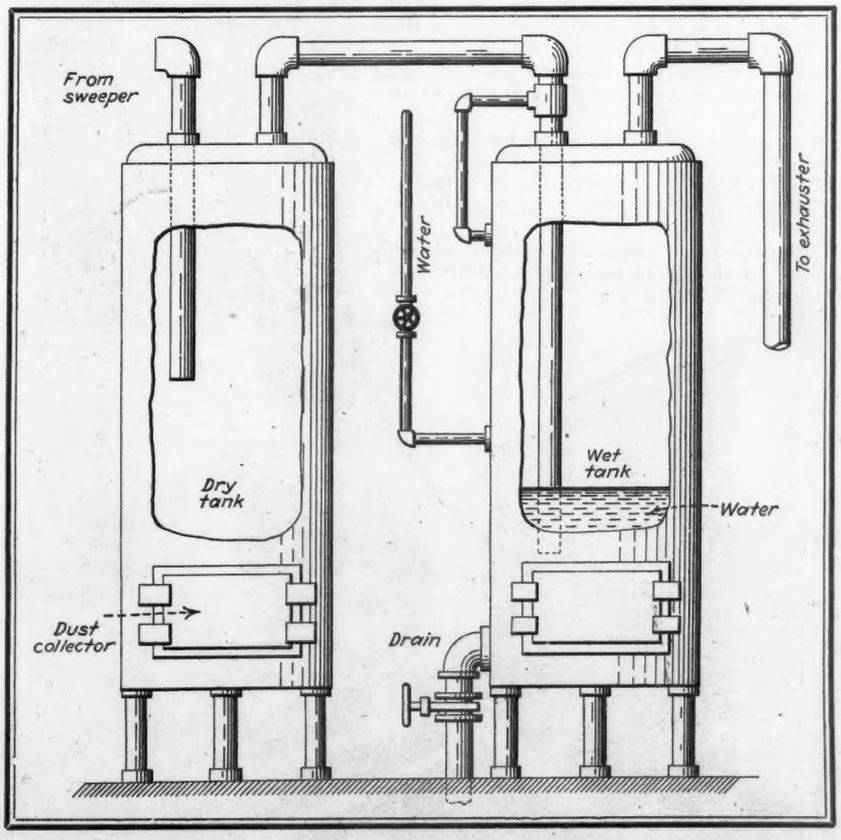
Keeping the bags clean is an important part of the operation of a bag filter, and demands close attention. If the dust is allowed to accumulate to too great a depth on the inside of the bag, the resistance to the passage of the air is materially increased, which increases the power required to operate the system.

It is hardly to be expected that any one set of filter cloths or bags could be used for handling a variety of dusts. Even in the same industry different cloths are required for various steps or processes. Also, special precautions must be taken to prevent fire. Metal screens are commonly used to filter hot mixtures.

Where it is immaterial, or is desired, that moisture be added to the air, wet filters are frequently used. This is especially true when recirculating heated air in a building. In a wet filter, air passes through a mist or curtain of water in an air chamber and has all foreign particles washed out. In addition, it picks up moisture which is a desirable and necessary element in a hot air heating system. Recirculated air is sometimes treated with ozone to revitalize it.

In wet separators the dust-laden air is passed through water before it is exhausted. This washes out the dust and exhausts clean, moist air. This is ordinarily not done unless the air is to be used again, such as for recirculating in heating and ventilating systems or for use in processes, because a small amount of dust in the exhaust is seldom considered harmful. The dust settles to the bottom of the water chamber and is flushed out either into the sewer or into a settling tank. Seldom is such dust of any value.

One of the important parts of all

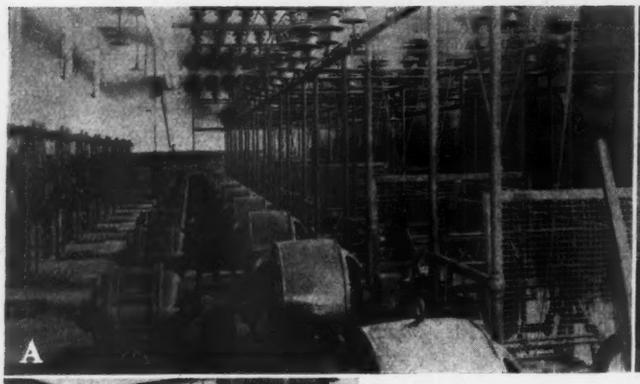


In this case dry tanks and wet tanks are both used.

Equipment of this sort is frequently used in connection with pneumatic sweepers. The first tank removes all the heavy solid materials and most of the dust. Any dust carried over in the air is separated by passing through the water in the second tank.

Equipment for Separating Dust from Air

Ten Examples of Applications in Industrial Plants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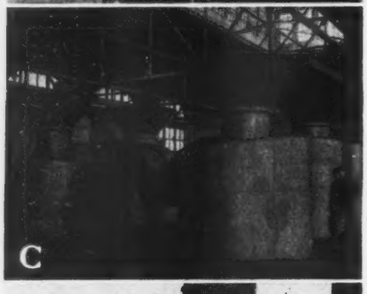
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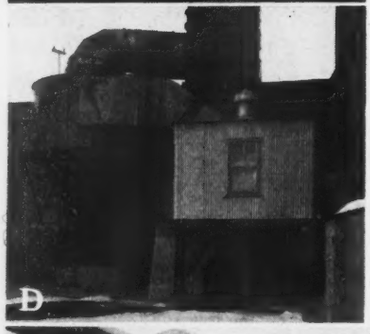
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A—This shows a portion of an installation of 24, 10-kva., 75,000-volt, General Electric generator sets, transformers and switchboards which supply high-voltage current for a Cottrell precipitation service.

B—These bags hold five days' catch of dust obtained in a Cottrell precipitator at the plant of the Riverside Portland Cement Co.

C—This battery of four compound centrifugal separators recovers about 40 tons daily of kiln dust in a cement mill.

D—Here the outlet from the cyclone separator discharges into a stack instead of into the open air.

E—In this installation the dust-laden air passes through a series of screens. Dust deposited on these screens is loosened at frequent intervals by jarring and is removed from the hopper at the bottom.

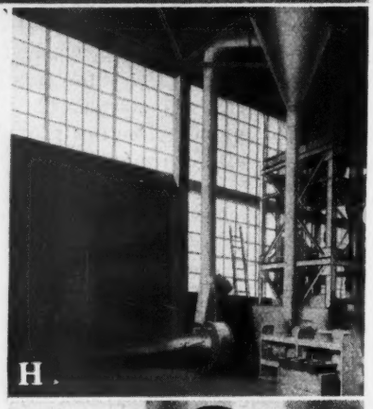
F—This bank of sectional unit filters is installed on the inlet to a ventilating system.

G—Here a stationary vacuum cleaner with its two filter tanks is used for general sweeping in the coating room of a wallpaper plant.

H—In this installation a cyclone separator removes the grinding dust exhausted from a group of emery wheels.

I—This battery of compound wet and dry separators handles 80,000 cu. ft. of air per min. The bulk of the dust is removed dry centrifugally and the remaining fine dust is washed out centrifugally.

J—Six sectional unit filters are installed on each side of a heater supplying air to a finishing and drying room.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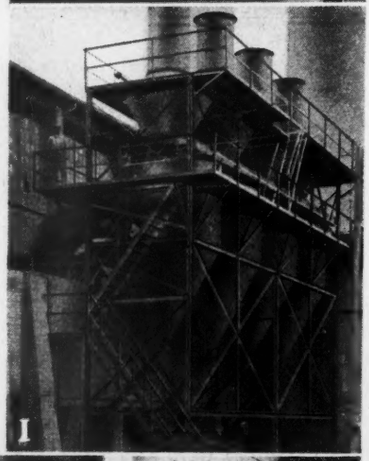
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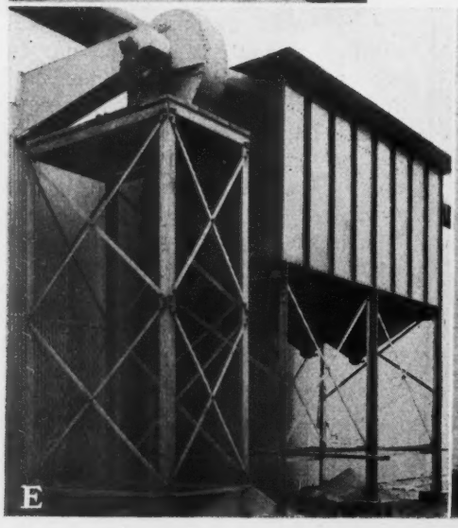
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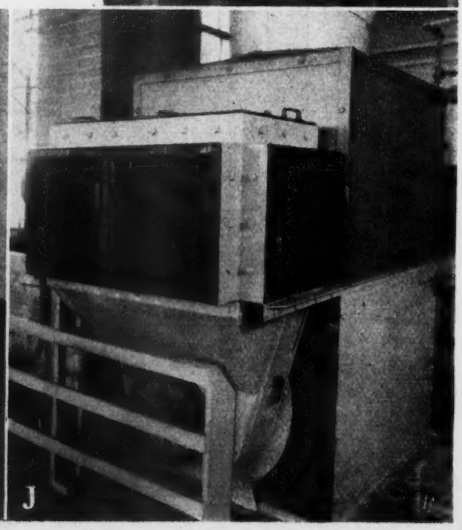
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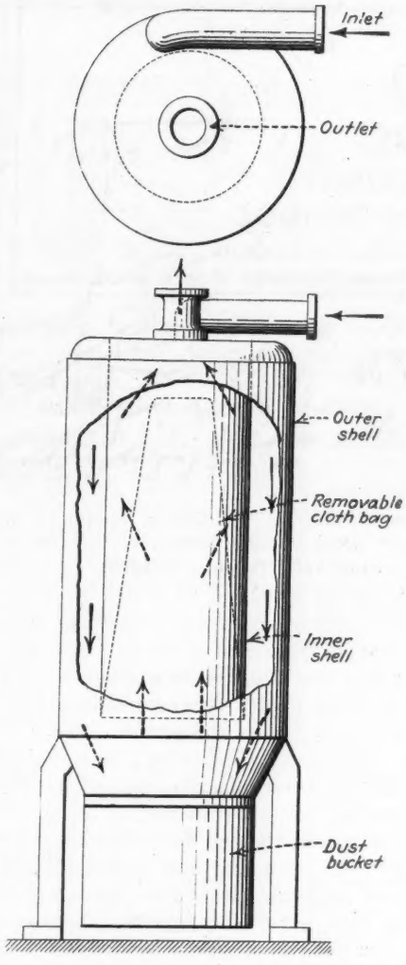


This is one type of combination centrifugal and bag filter.

The dust-laden air enters the centrifugal separator at the top and loses practically all solid material as well as much of the dust in its passage around the circumference of the separator between the outer and inner shells. The dust and heavy material fall into the dust bucket. Any fine dust remaining in the air rises upward and is removed as the air passes through the removable cloth bag.

wet air filters is an adequate settling tank, if the water is to be recirculated. Another point which is often neglected is seeing that wet filters are of substantial construction.

Frequently the wet and dry systems are combined. The heavier dusts are removed by the dry process and the fine dust washed out as described. An outfit for this purpose in which the dry tank, at the left, operates by changing the direction of the air current, is shown in the sketch on page 367.

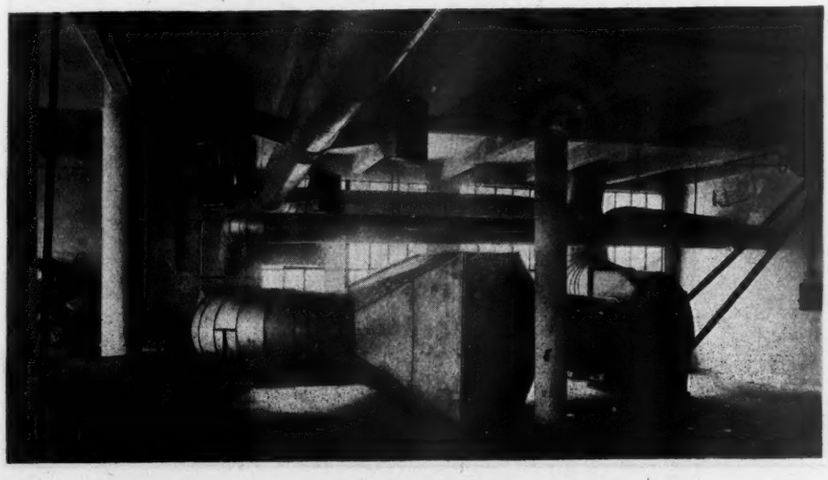
There is a large variety of types of wet and dry filters. Many of the dry filters are made of cloth and differ largely in the arrangement of the cloth, either in the form of screens or bags, and in the provision for cleaning and emptying. In any case it must be remembered that cloth or other filters should not be forced too much, or the increased pressure or vacuum will drive particles through the filter. The remedy is to increase the surface area of the filters. Whenever an installation is planned, it is well to take up all details of the operating conditions with the manufacturer, and particularly to consider the maximum capacity which the filter will be called upon to deliver at any time.

Some of the more common industrial operations which require clean, filtered air are in connection with the cooling of machinery in operation or the air used in a machine, such as on turbo-generators, motors, air compressors, pneumatic tools, air brakes, gas engines, etc., Filtered air protects the equipment from accumulations of dust and from undue wear. Also, it is frequently necessary to use dust-free air in the manufacture of certain products, such as food products, fine chemicals, photographic plates and films, some textile fabrics and in other processes. Either wet or dry systems are commonly used in connection with ventilating equipment for offices and factories, as they not only remove the dust but many germs. In some industries, such as food product plants, it is frequently necessary to have air practically free from bacteria.

One of the big problems in industrial plants is in connection with the operation of turbo-generators and large motors, particularly in steel mills. In these cases it is frequently necessary to use forced circulation of air through the equipment to help keep it cool. Unless the air is clean, dust accumulates on the windings. For this reason the air surrounding the equipment could hardly be used without some treatment. In one steel mill, for example, two large fans delivering 90,000 cu. ft. of air per min. force incoming air through an air washer for cooling and cleaning before supplying it to two large reversing mill motors and motor generator sets, in addition to seven smaller auxiliary mill motors out in the plant. In another case the main motors and generator sets are installed in a special room which is kept under a slight pressure, just about that of the atmosphere, so that no atmospheric dust can enter. Cleaned air is forced into this room as well as through the machines, to keep them cool.

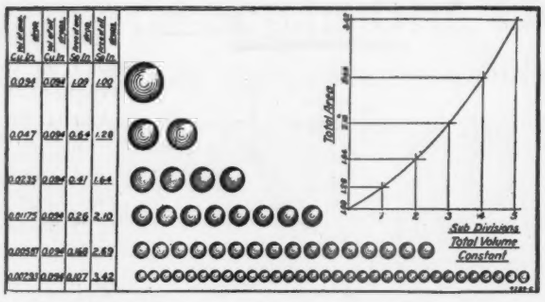
In addition to the types of wet filters already described, there is other special equipment commonly known as scrubbers. While these were originally designed for use in connection with removing dust and particles from hot gases, they are frequently used in many other applications for dust removal.

One type of these is a combination centrifugal wet scrubber. In this the incoming gas is passed through a revolving disk with a large number of pins projecting outward at an angle and staggered. This disk is rotated at high speed and water, oil or other liquid flows down and over the wheel. The high speed forces the liquid out through and around the projecting pins. The gas passes through this and up around the outer shell and into the outlet. The high speed of rotation, it is claimed, forces the particles of dust into the



In some food products plants bacteria which are carried on dust must be removed.

Here the air discharged into the room is first passed through special filters, the large square objects at the end of the short extension from the pipe at the ceiling. In this way the dust is removed along with any bacteria it may be carrying just before the air enters the room. This installation is in a gelatin factory.



How fineness of mist affects wet washing.

In wet washers a fine mist will present more wet surface to catch the dust, than if the drops are heavier. This table shows the relation of the surface area of various sizes of water particles where the volume of each group of particles is the same. For this reason the fineness of the mist as well as its density is important.

liquid which flows down through the settling chamber and out. Oil is used where it is not desired to increase the humidity and certain chemical solutions are used where it is desired to absorb certain elements out of the gas. It is claimed that with the use of oil practically 100 per cent of the dust may be removed. In starch mills, for example, the starch water is recirculated until it gets heavy with starch. It is then drawn off and reprocessed, thus saving what formerly went to waste.

Electrical Precipitation of Dust or Fumes from Air

There is still another method of removing dust and fumes from air or smoke before it is discharged into the atmosphere. This is known as the Cottrell electrical precipitation process and was originally developed for use in settling acid mist, created in the manufacture of acid, so that it would not be discharged into the atmosphere. In addition to the wide use of this process in depositing vapors created in chemical processes, it is also widely used in removing solid materials, such as dust, from air and fumes.

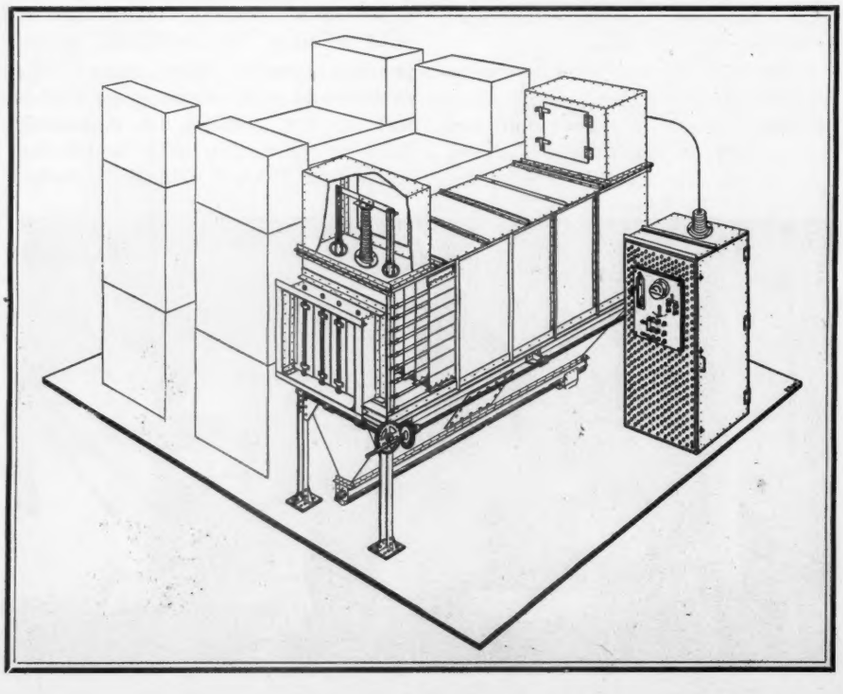
The electrical precipitation of dust consists in passing dust-laden air or gas between two oppositely-charged elements, one being a wire known as the "discharge electrode" and the other a plate or "collecting electrode." With proper conditions of electrical potential and velocity of the air or gas, the dust will be precipitated on the collecting electrode, and the air or gas will pass through unaffected. The precipitation apparatus consists of a number of wire electrodes and plates, together with the electrical equipment to produce the high potential discharge required. The electrical equipment consists of a small switchboard, a synchronous motor and mechanical rectifier, and a transformer; these produce a unidirectional current at an operating voltage of 30,000 volts or more. The potential is maintained on the precipitator or collector at a voltage at which there is a "corona" or silent electrical discharge from the wire to plate and below the point where there would be a disruptive or arc discharge between the wire and plate.

This equipment is built in units so that at intervals, determined by the amount of dust collected on the plate, the power and the flow of air may be cut off from one unit automatically and the plate cleaned by mechanically jarring or vibrating the electrode. The dust or other material falls into hoppers and is drawn off as desired by screw conveyors or other means. The automatic damper control, power switching and electrode cleaning devices are interlocked and synchronized.

Where the problem involves elimination of a dust nuisance the efficiency of operation is so adjusted that the nuisance will be reduced to a minimum consistent with economy of operation.

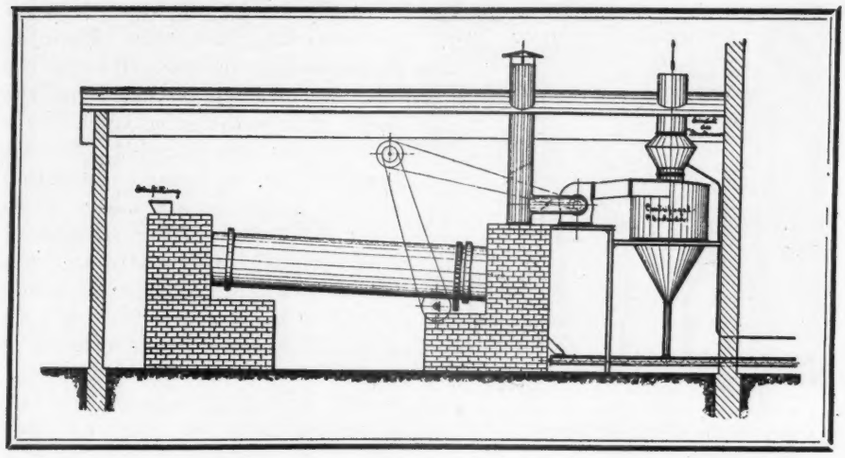
For some work standardized units may be used. One of these is shown in an illustration on this page. The capacity of the units depends upon the efficiency of removal desired. When operated at 90 per cent efficiency, for example, a much larger quantity of air may be handled than if 99 per cent efficiency is desired. For larger volumes additional units may be added either in series, in parallel, or in series-parellel. Electrical power consumption of two such standard units is approximately 1.5 kw. But little attention need be given to this equipment, other than occasional inspection of the electrical equipment and periodical cleaning and attention to the precipitator. There is very little wear on the precipitator parts from the abrasive action of fine dust. For this reason, the depreciation on the equipment as a whole is small. Also, but little back pressure, and that is uniform, is created by this apparatus.

The efficiency is independent of the dust content of the gases. If the air or gas contains constituents which are corrosive, special materials can be used in the construction of the equipment. Where food products are recovered, not only are special materials used, but provision is made to cleanse and sterilize the apparatus. Bacteria are destroyed by this process of removing dust and



One type of standard unit construction in the Cottrell electrical precipitation process.

As the dust-laden air passes through this equipment the dust is deposited on the "plate" electrode as described in the text. A high-potential, unidirectional current of approximately 30,000 to 50,000 volts causes this precipitation. The dust or other material is collected in hoppers at the bottom and drawn off by a screw conveyor.



In this case combination wet and dry separators are used so that no dust escapes.

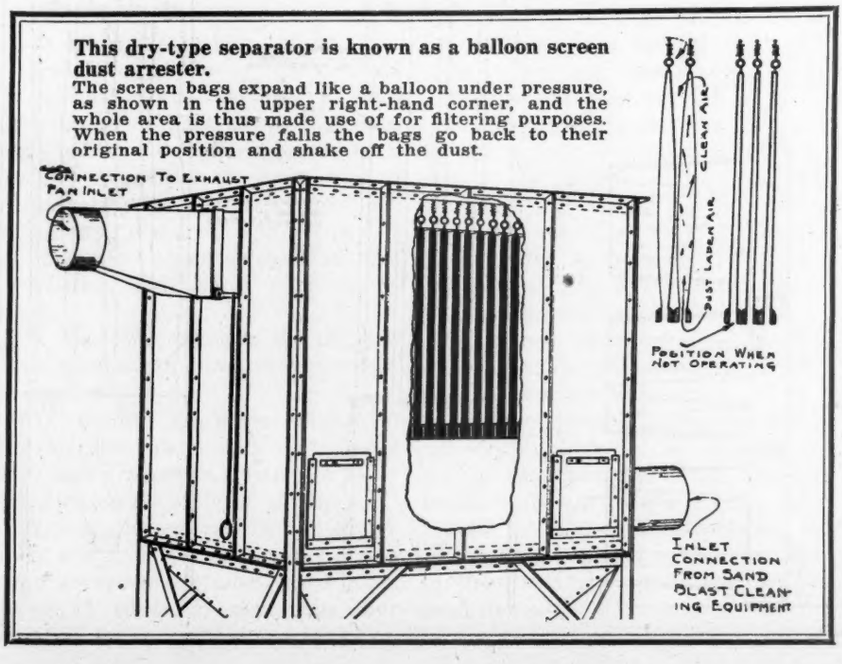
This type of dust collector is used in connection with dryers handling crushed clay or limestone. Here a fan drives the waste gases from the closed dryer stack and blows them to the cyclone separator in which the greater part of the dust is settled in a dry condition. The remainder, consisting mostly of fine dust particles, is delivered from the cyclone separator to the wet centrifugal separator which is here placed on top of the dry separator. In this wet separator the air is forced to travel in several alternating directions and passes through several fine water mists produced by special spraying nozzles. By this treatment the dust is softened and then precipitated by centrifugal force, thus rendering the escaping air practically dustless. This process is also used with other types of rotary kilns such as in cement plants and also with coal dryers. Combination wet and dry separators are often used where it is desired to recover as much of the dust as possible (dry) and also prevent (by the wet process) any fine dust from being discharged into the atmosphere.

particles. It is believed that they are killed by the corona.

The electrical precipitation process is used for the recovery of copper, lead, tin, zinc, silver, gold and other metals carried away in the fumes and dust from sintering machines, reverberatory and blast furnaces, converters, roasters, dryers and other metallurgical equipment. Also, as previously mentioned, it is widely used for the precipitation of acids and other chemical liquids. The electrical process is also used to remove smoke, soot and ashes from boiler plants, gases from engine roundhouses where such discharge would be especially objectionable in the city, and in the removal of solid particles from blast furnace gas before its use in engines or furnaces.

This process has also been used for cleaning air from foundries, and machine rooms, for the precipitation of slate dust from crushing operations, to deposit potash from cement kilns and in many other similar processes. Where the dust has a value such precipitation in many cases more than pays for itself. This process, of course, requires the use of a fan and ducts to carry the air from the process and through the precipitator, the same as any other filtration process.

Because even atmospheric air contains a considerable amount of dust, under normal industrial conditions, it is frequently necessary to remove this dust before the air can be used in processes or in connection with equipment. This also is a problem common to a large number of industries. For removing this dust, wet or dry filters may be used, as was the case in filtering outgoing air.

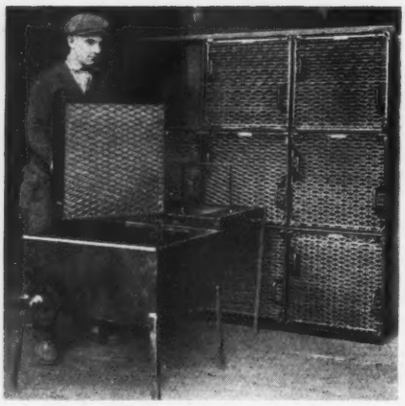

CONNECTION TO EXHAUST FAN INLET
CLEAN AIR
DUST LADEN AIR
POSITION WHEN NOT OPERATING
INLET CONNECTION FROM SAND BLAST CLEANING EQUIPMENT

This dry-type separator is known as a balloon screen dust arrester.

The screen bags expand like a balloon under pressure, as shown in the upper right-hand corner, and the whole area is thus made use of for filtering purposes. When the pressure falls the bags go back to their original position and shake off the dust.

There is still another type of filter that is very frequently used for this purpose, but has not been described. This consists of a number of cells or filter units in the form of a shallow steel box having perforated sheet metal covers in the front and back and filled with special filter material. These filter materials may be special filter sheets, filter bodies, or a combination of both, depending upon the purpose of the filter. All the surfaces exposed to the passing air are covered with a thin film formed by dipping the unit into a non-evaporating, non-inflammable viscous and adhesive solution. The dust particles in the air are deposited upon this adhesive solution as the air passes through the filter material. The sections or cells are cleaned by dipping them in a solution which dissolves the viscous material which has caught the dust and washes the dust away with it. The filter unit is then dipped into a fresh viscous solution, allowed to drain and is again ready for use. A few spare units are kept on hand to be inserted when units are removed for cleaning. The cleaned unit then becomes a spare. The length of time between each cleaning depends upon the amount of dust handled. Some of these filter installations and the method of cleaning are shown in accompanying illustrations. Each of these is rated at a stated capacity.

In any installation it is merely a problem of providing enough filter units to handle the required volume of air. This type of filter may be used as well for handling outgoing air, although in general it is not necessary to remove as high a percentage of dust as it is capable of doing. A very common use of these filters is in connection with the inlet of air compressors. Removing solid material from the air prevents scor-



One of the steps in cleaning a sectional filter unit.

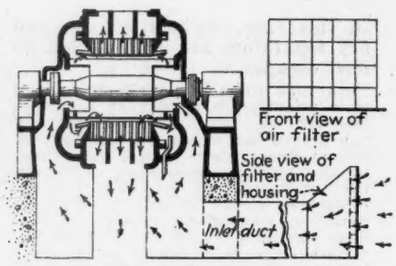
A unit is cleaned by dipping it into a solution which dissolves the viscous material, which catches the dust, from the surfaces in the filter unit. This also washes the dust away. The clean unit is then dipped in a fresh viscous solution. After draining, as shown here, it is set away to use as a spare at the next cleaning period.

ing of air cylinders and so increases the life of the compressor. In addition, if the dust is removed from the air, there is less danger of it getting into tools, such as air drills and hammers, and interfering with their operation. Filtering is also desirable where compressed air is used in a process, such as, for agitating or aerating liquids. This type of dry filter is frequently used where it is not desired to add any moisture to the air.

Another point to be emphasized in connection with all dust removal problems is that more attention should be placed upon collecting the dust before it has escaped into the room. It is well to give much attention to the attaching of the duct systems and enclosing construction because to do so will assist materially in reducing the amount of dust escaping. In modern systems, the machines and conveyors are connected to the exhaust fans in such a way that the dust is removed at the point where it originates.

The preceding articles of this series on materials which are handled by air have so far covered only light dust, fumes and other products which float to a certain extent in air. However, air is used to a considerable extent to carry much heavier materials. One of the most common of these is shavings. In addition, air is also used to carry wool, cotton and many solids in a pulverized and semi-pulverized form. The use of air for this purpose will be discussed in a later article.

EDITOR'S NOTE: Special acknowledgment is made to the following companies for assistance in furnishing information, data and illustrations for this and other articles which are appearing in this series: The Air Conditioning & Engineering Co., St. Louis, Mo.; Allen & Billmyre Co., Inc., New York City; American Blower Co., Detroit, Mich.; Autovent Fan & Blower Co., Chicago, Ill.; E. B. Badger & Sons Co., Boston, Mass.; Bentz Engineering Corp., Newark, N. J.; Buffalo Forge Co., Buffalo, N. Y.; Carrier Air Conditioning Co. of America, Buffalo, N. Y.; Carrier Engineering Corp., Newark, N. J.; The Clarage Fan Co., Kalamazoo, Mich.; The Cooling Tower Co., Inc., New York City; The Dust Recovering & Conveying Co., Cleveland, Ohio; General Electric Co., Schenectady, N. Y.; Globe Ventilator Co., Troy, N. Y.; Green Equipment Corp., Chicago, Ill.; Holly Pneumatic Systems, Inc., New York City; Ilg Electric Ventilating Co., Chicago, Ill.; The MacLeod Co., Cincinnati, Ohio; The Martindale Electric Co., Cleveland, Ohio; Mellish-Hayward Co., Chicago, Ill.; Midwest Air Filters, Inc., New York City; D. J. Murray Mfg. Co., Wausau, Wis.; The Northern Blower Co., Cleveland, Ohio; Research Corp., Chicago, Ill.; Reed Air Filter Co., Inc., Louisville, Ky.; Spray Engineering Co., Boston, Mass.; B. F. Sturtevant Co., Boston, Mass.; The Temco Electric Motor Co., Leipsic, Ohio.

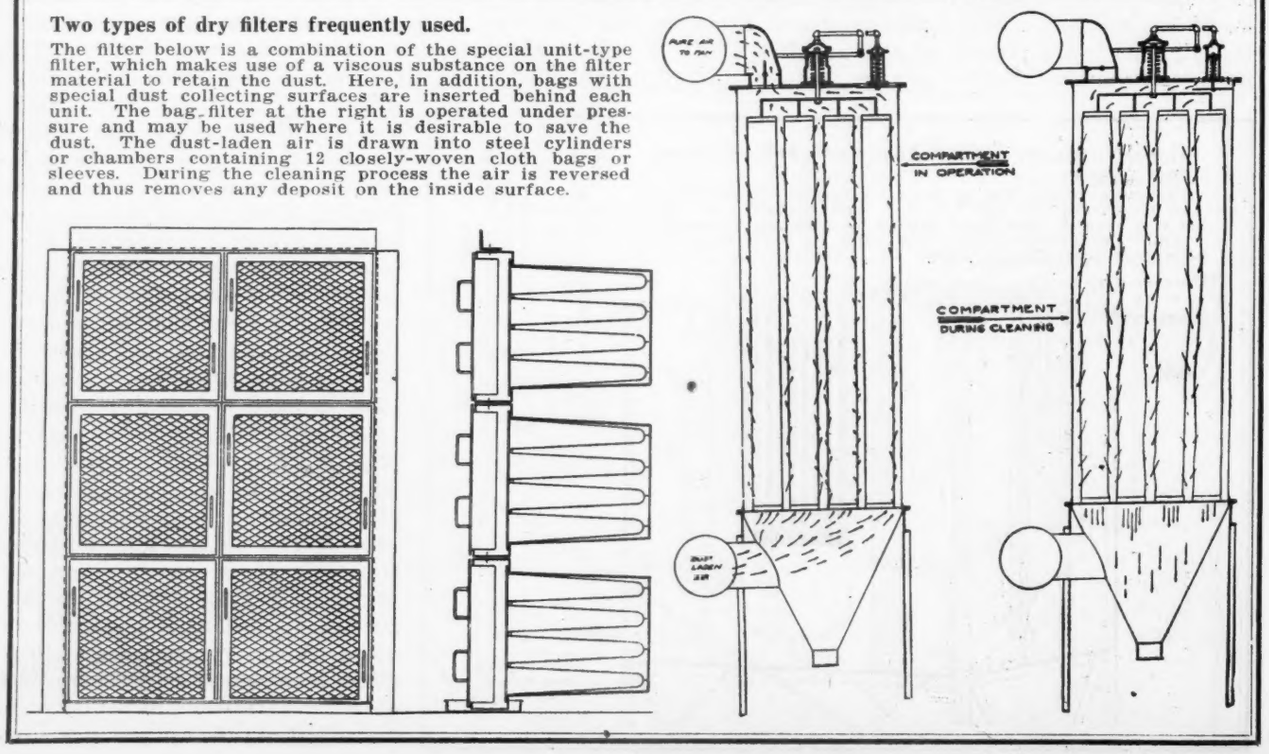


An example of the use of unit sectional filters to clean the air circulated through a generator.

It is quite frequently necessary to circulate air through large generators and other electrical equipment to keep it cool. Unless this air is first cleaned and freed from dust and lint, much of the dust would be deposited upon the windings and form a potential source of trouble.

Two types of dry filters frequently used.

The filter below is a combination of the special unit-type filter, which makes use of a viscous substance on the filter material to retain the dust. Here, in addition, bags with special dust collecting surfaces are inserted behind each unit. The bag-filter at the right is operated under pressure and may be used where it is desirable to save the dust. The dust-laden air is drawn into steel cylinders or chambers containing 12 closely-woven cloth bags or sleeves. During the cleaning process the air is reversed and thus removes any deposit on the inside surface.

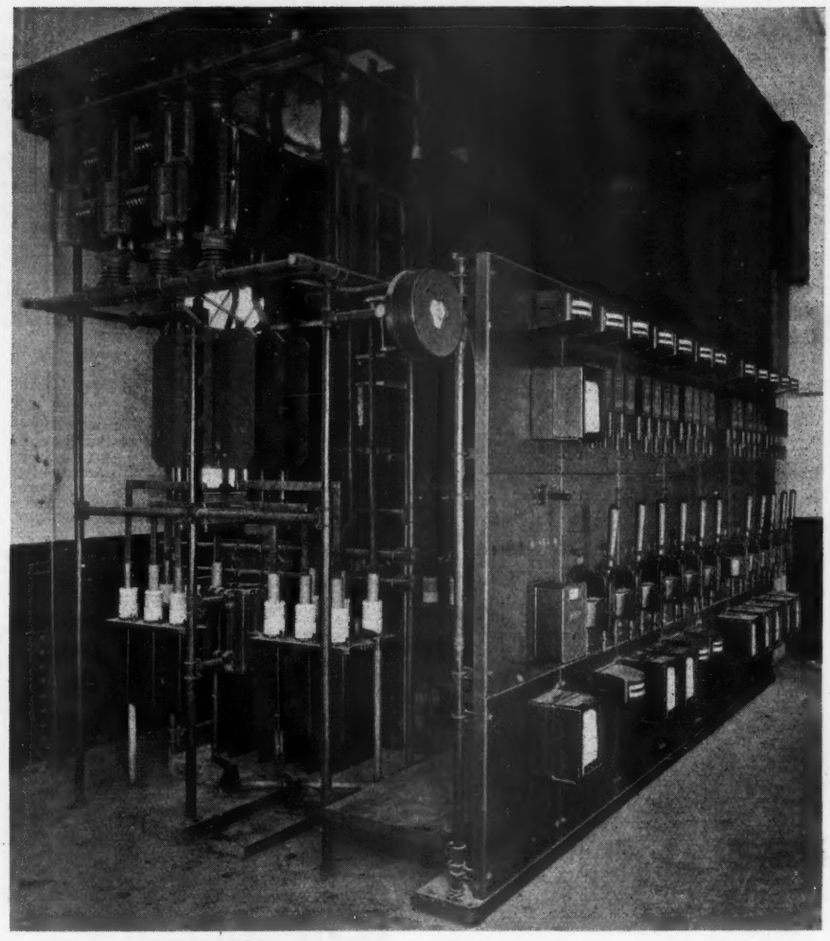


USEFULNESS AND reliability of any piece of electrical equipment depend to a large extent on the skill and care with which it is installed and the attention that it receives while in service. Some types of equipment naturally require more care than others, but continued neglect of any kind of equipment is certain to cause trouble sooner or later. Oil circuit breakers and switching equipment in general are by no means exceptions to this general rule. Instructions given in this article have been prepared to bring to the attention of operating and maintenance engineers the points that should be given especial attention while this equipment is being installed and after it is in operation.

Electric Power Club Instructions for

Installing Oil Circuit Breakers

And Power Switching Equipment With Pointers on the Care and Operation Thereof



This shows one of the power switchboards in a large tire factory. In order to save space, which was limited, the circuit breakers were mounted back-to-back. This made it possible to put eleven oil circuit breakers on six panels. Note the rigid mounting of the double-deck bus, on the pipe framework. The circuit breakers operate at 440 volts and range in capacity from 600 to 1,200 amp. Courtesy of Electrical Engineers Equipment Co., Chicago, Ill.

IN THE July issue, there were presented instructions which have recently been prepared by The Electric Power Club for the installation, operation and maintenance of power switchboards. Similar instructions which have been prepared to cover the installation, operation and care of oil circuit breakers and power switching equipment are given in this article.

The Electric Power Club is an association of manufacturers of electric power apparatus and control equipment, which was organized to devise standards of practice and construction in the design and application of electrical equipment, and to promote advancements in the production and use of such equipment.

In the introduction to the instructions mentioned above, this comment is made:

"Oil circuit breakers require a considerable amount of intelligent care and inspection to insure their functioning properly at all times.

"Other power switching equipment requires less care, after it has been correctly installed, than most types of electrical apparatus, but neglect of certain fundamental requirements may lead to serious trouble."

These instructions are as follows:

STORAGE

When an oil circuit breaker can be set up immediately in its permanent location and filled with oil, it is advisable to do so, even though it will not be placed in service for some time. The tank should be cleaned and dried before it is filled with oil.

If the breaker cannot be installed in the proper location immediately, and it is necessary to store the equipment, it should be kept in a clean, dry place. It must not be exposed to dirt, to the action of corrosive gases, such as chlorine, or to possible mechanical injury.

If stored outdoors, the breaker must be thoroughly covered to protect it from the weather.

Machined parts of operating mechanisms, etc., should be slushed to prevent rusting; and if the breaker is stored for any length of time, they should be inspected periodically to see that rusting has not started and to insure their good mechanical condition.

Particular care should be taken to protect insulating parts, which might absorb moisture. It is desirable that these parts be stored in a dry room.

LOCATION

The circuit breaker should be placed in a clean, dry place free from the destructive action of acids, alkalies or gases, such as chlorine, and where good ventilation can be secured.

The breaker should be so located that it will be readily accessible for cleaning and inspection. Sufficient space must be provided for the easy removal of the oil tanks.

The instructions sent by the manufacturer should be carefully studied and followed in order to

secure the best results. It is here impossible to cover in detail the complete rules for installation of each of the different types of oil circuit breakers manufactured, but the following information is given relative to the most important points to be considered:

MOUNTING

On Slate Panels.—When an oil circuit breaker is mounted on a slate panel, do not over tighten the holding bolts and nuts supporting the breaker, as unnecessary strains may crack the slate.

On Framework.—If the oil circuit breaker has been shipped assembled in its framework, it will only be necessary to correctly locate and fasten the frame in position on its foundation. The foundation bolts should be left loose to permit the frame to be properly plumbed and leveled by inserting shims under floor flanges (or feet of frames) where necessary. After this has been done, the foundation bolts should be tightened and the frame securely fastened to its foundation.

The manufacturer's instructions should be carefully followed in regard to properly setting up a frame-mounted breaker shipped partly disassembled. The procedure is:

(1) Set up and properly level the frames.
(2) Carefully install the units on the framework, making sure they are level.
(3) Connect the operating mechanisms.
(4) Inspect contacts and adjust (if necessary) as per instructions sent with the breaker.

Floor Mounted.—Each tank should be placed in position on the floor and leveled. It should not be fastened securely to its foundation until the current breaker mechanism has been correctly aligned.

The manufacturer's instructions should be followed very carefully, making sure of the following points:

(1) Carefully install the units on the foundation, making sure they are level.
(2) Connect the operating mechanisms so they will work freely as per instructions.
(3) Inspect contacts and adjust, if necessary, as per instructions sent with the breaker.

Bushings.—The bushings (insulators) must not be allowed to strike against parts of the framework, panel or other objects, when installing or handling the breaker. Bushings are often broken, cracked or loosened in their supports by unnecessary jars due to careless handling.

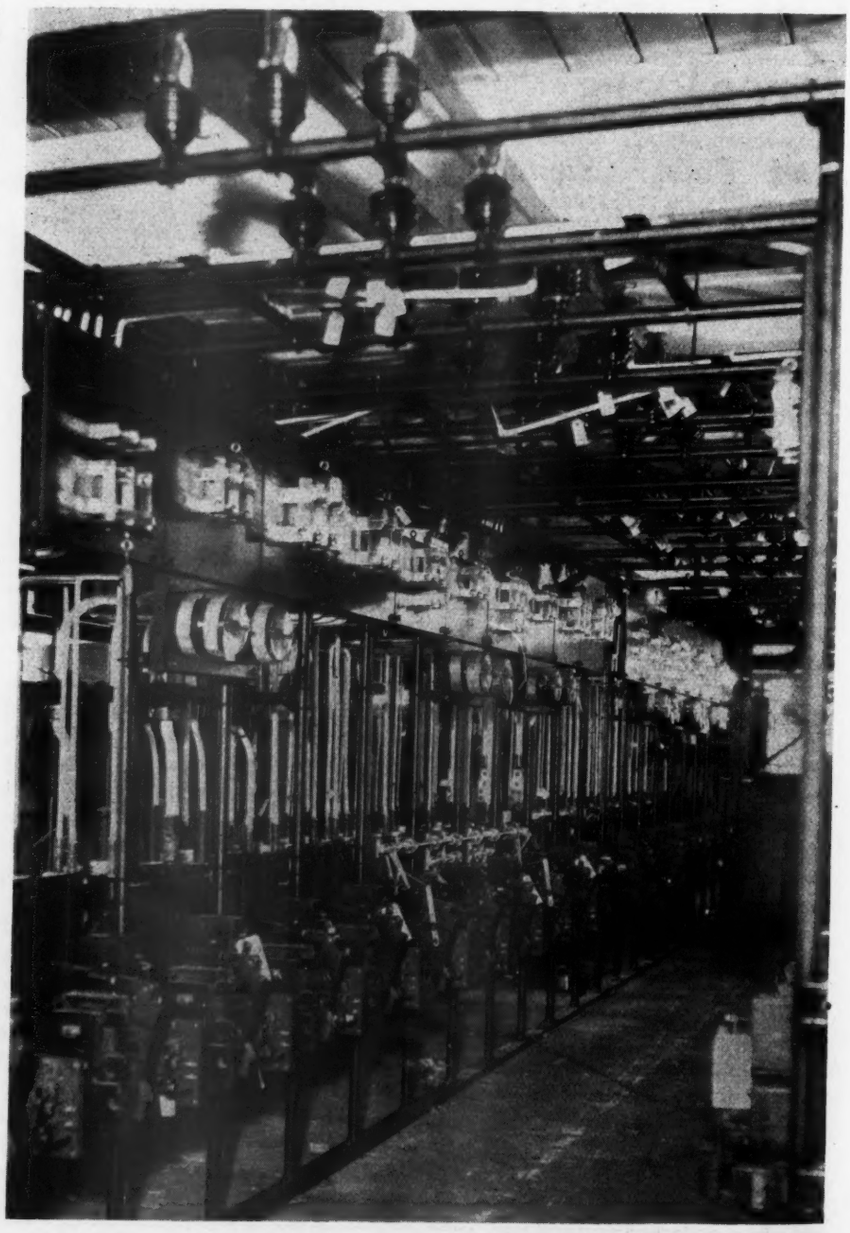
Where heavy bushings have to be mounted in position by the purchaser, a rope sling will be found convenient for proper handling. The bushing must be lowered into place very carefully without letting the porcelain petticoating strike the sides of the framework, etc., as this may crack or otherwise injure the bushing.

In the case of high-voltage bushings which must be filled with oil, the drain plug in the casting at the lower end of the bushing should be inspected to see that it is tight; otherwise the bushing will leak oil.

Operating Mechanisms.—As the proper alignment of the links, pins, etc., of the operating mechanisms is essential to the proper operation of the oil circuit breaker, these should be carefully checked and the manufacturer's instructions followed explicitly. A breaker must not be operated until a thorough inspection is made of the mechanism.

For large, triple-pole breakers, the connecting rods or couplings between units must be aligned before satisfactory operation is possible. The connecting rods or couplings must be adjusted so that, in closing the breaker, the contacts of each unit are made at the same instant and in opening the breaker, the contacts of

Here is a well-planned installation of circuit breakers.
This is a 440-volt, three-phase, 60-cycle installation. The advantages of pipe framework as a mounting structure are clearly apparent in this and some of the other illustrations. Note how the buses are mounted on pipe supported at the top of this and another similar board, part of which can be seen at the entreme right of this illustration. Courtesy of Condit Electrical Mfg. Co., Boston, Mass.



each unit break at the same instant.

Contacts.—Contacts should be adjusted in strict accordance with the manufacturer's instructions sent with the individual oil circuit breaker.

Before opening or closing the contacts they should be coated with vaseline. (In most cases this is done by the manufacturer before shipment.)

Manually-Operated Oil Circuit Breakers.—If the lever, handle or crank has not been connected to the operating mechanism by the manufacturer for operating the breaker manually, this should be done, making sure that all parts (shafts, pins, etc.) are properly lined up as per the manufacturer's instructions. Before attempting to bend or force parts together when installing, the manufacturer's instructions should be referred to to see if they have been explicitly followed. Much time and trouble may be saved by avoiding too hasty action.

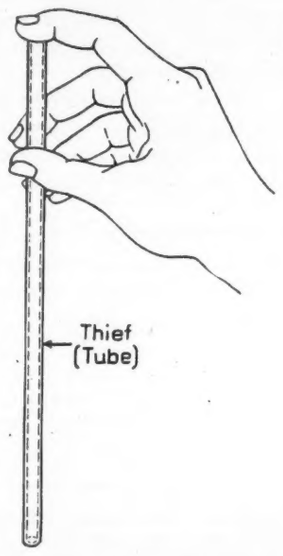
Electrically-Operated Oil Circuit Breakers.—The connecting links, shafting, etc., between the breaker operating mechanism and the mechanism (solenoid, motor or other device) supplied for electrical operation, must all be carefully aligned. The breaker should be slowly operated by hand before it is operated electrically. The operation should be observed to see that it is smooth throughout the closing and opening of the breaker, that no binding occurs, and that no excessive play is noticeable between parts.

Sampling and Testing Oil

When sampling oil the sample container should be a large mouthed glass bottle. The bottle should be cleaned and dried with gasoline, free from moisture before it is used. A cork stopper should be used.

The sample of oil for dielectric tests should be at least 1 pt. (16 oz.) and if a number of tests are to be made, 1 qt. (32 oz.).

Test samples should be taken only after the oil has settled for some time, varying from 8 hr. for a barrel to several days for a large oil circuit breaker tank. Cold oil is much slower in settling and may hardly settle at all. Oil samples from large oil circuit breakers should be taken from the valve at the bottom of the tank. Oil samples from small oil circuit breakers which have no valves, and from barrels, should be taken from the bottom. A brass or glass "thief" can be conveniently used for this purpose. The same method should be used for cleaning the "thief" as is used for cleaning the container for the oil sample.



This shows how to hold the "thief" for taking samples of oil from small oil circuit breakers.
The oil tank should be lowered and the sample taken at a point about half-way between the closed contacts and the bottom of the tank. The finger should be held tightly over the upper end of the thief or tube, while the lower end of the thief is pushed down in the oil to the proper level. When the finger is removed the oil will flow into the thief. The upper end should again be closed with the finger, after which the thief may be withdrawn from the oil and the sample deposited in any suitable container. Courtesy of General Electric Co., Schenectady, N. Y.

When drawing samples from the bottom of a large oil circuit breaker or large tank, sufficient oil must first be drawn off to make sure that the sample will be composed of oil from the bottom of the tank, and not from the oil stored in the sampling pipe. A glass receptacle is desirable so if water is present, it may be readily observed. If moisture is found, an investigation of the cause should be made and a remedy applied. If water is not present in sufficient quantity to settle out, the oil may still contain considerable moisture in a suspended state. It should be tested for dielectric strength.

In testing oil for dielectric strength, some standard device for oil testing should be used. The standard oil testing spark gap has disk terminals 1 in. in diameter spaced 0.1 in. apart. The testing cup should be cleaned thoroughly to remove any particles of cotton fibre, etc., and rinsed out with a portion of the oil to be tested.

The spark gap receptacle (cup) should be nearly filled with oil and allowed to stand for a few minutes to give air bubbles time to escape before making the test.

The rate of increase in voltage should be about 3,000 volts per second. Five breakdowns shall be made on each filling and then the receptacle emptied and refilled with fresh oil from the original sample. The average voltage of 15 tests (5 tests on each of 3 fillings) is usually taken as the dielectric strength of the oil. It is recommended that the test be continued until the mean of the averages of at least three fillings is consistent.

The dielectric strength of the oil when shipped is at least 22,000 volts tested in the standard gap. If the dielectric strength of the oil in an oil circuit breaker in service tests at less than 16,500 volts, it should be filtered. New oil of less than the standard dielectric strength (22,000 volts) should not be put in the oil circuit breaker tank.

Drying.—In removing moisture from the oil, it is preferable to filter from one tank or barrel and discharge into another, although if necessary, it may be drawn from the bottom of a tank or barrel and discharged at the top. When there is much water in the oil, it should be allowed to settle; then the moisture should be drawn off and any moisture remaining treated separately.

Filling Tanks.—Before the oil circuit breaker is filled with oil, all accessories, such as valves and gages must be fitted to the breaker and made oil tight. The threads should be filled with shellac before putting in place.

When drums of oil are brought into a room warmer than they are, they should be allowed to stand before opening until there is no condensation on the outside and until they are thoroughly dry. If the installation is outdoors, the preparation and filling of the breaker tank should be done on a clear, dry day or protection of some kind provided against moisture being absorbed by the oil during the filling process.

Metal hose must be used instead of rubber hose, because oil dissolves the sulphur in rubber and may cause trouble, as sulphur attacks copper.

It is very important that the surface of the oil when cold (25 deg. C.) be at the proper oil level indicated by the gage or marking on the tank.

Before making any electrical connections every precaution must be taken to see that all leads to be connected to the oil circuit breaker are dead.

Leads should be brought down from above the circuit breaker if possible. Ample room must be provided between these leads and parts of the station, such as walls, channels and framework.

All terminals must be fastened securely to the leads and tightly clamped to the connection studs.

Connections to the breaker are made by copper tube terminals or connection bars fastened to the end of the bushing. When tightening the terminal or clamp bolts, care must be taken not to turn the stud in the bushing (insulator).

All joints must be clean, bright and free from dents or burrs.

All nuts on the current-carrying stud must be securely bolted against the terminal lugs to obtain good contact. The nut should turn freely on the stud. If the nut does not turn freely it should not be forced down with a wrench, but should be tapped lightly on its outer surfaces with a hammer and at the same time turned by hand. A nut that cannot be worked down in this manner will ruin the thread if any attempt is made to force it. If the joints are not made correctly, dangerous heating of the breaker may result.

Cables should be properly supported so that the breaker is not subjected to unnecessary strains. The studs should not carry cable or bus bar strains. Any strain which at first has no apparent effect on the stud alignment will in time force the studs to take up a new alignment, due to vibration during the opening and closing of the oil circuit breaker and poor contact may result.

To avoid heating, the connecting leads must be of a current-carrying capacity at least equal to that of the current-carrying part of the breaker.

To prevent weakening of the insulation as much as possible, sharp turns, corners and edges should be avoided, for insulated wiring. The radius of bends for rubber-covered, varnished-cambric or lead-covered cable should be never less than six times the outside diameter of the cable. With small braided conductors, the radius of bends may be five times the outside diameter of the cable.

Control Wiring.—All control wires should be run in conduit in so far as is practicable.

Control wires must be run separately and remote from high-tension leads and must not be run in the same duct or even run parallel to the high-tension leads unless the distance separating the two sets of wiring is sufficient to prevent possible communication between them as a result of short-circuits.

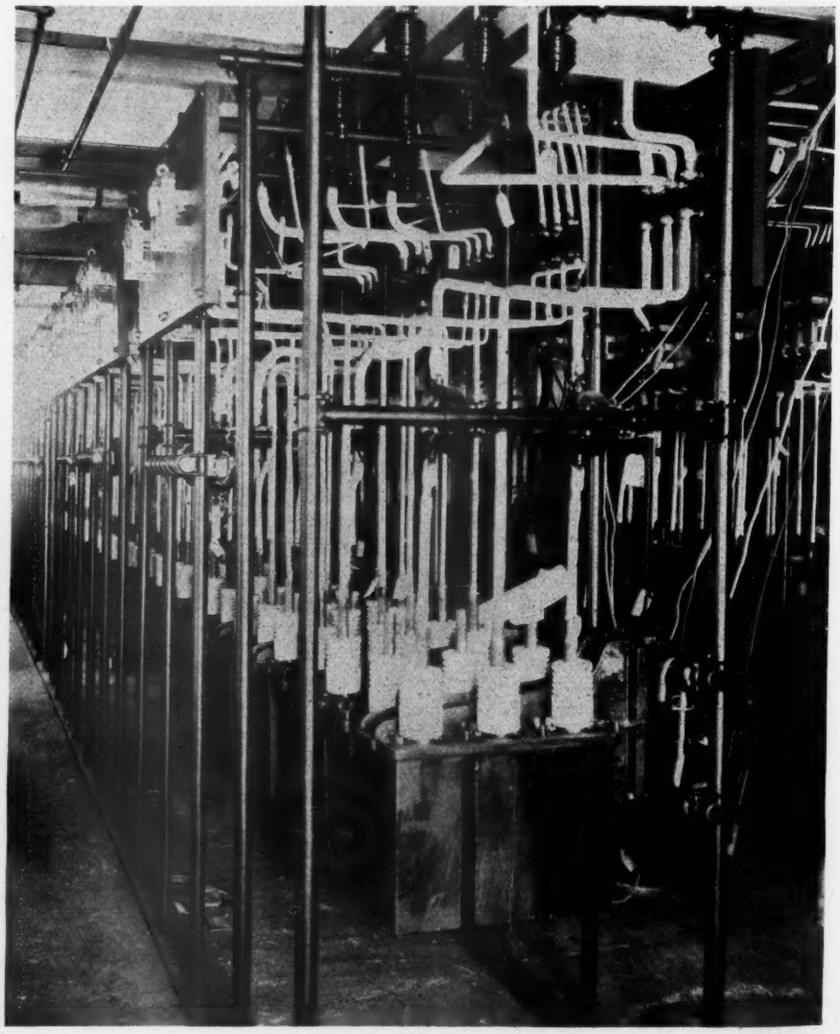
The control wiring should be so installed that trouble on one oil circuit breaker cannot be communicated to the control wiring of another breaker.

Ground Connections.—The frame of each unit of an oil circuit breaker should be permanently grounded. Usual practice is to connect a heavy cable to the frame and to the ground.

A good, permanent, low-resistance ground is essential for adequate protection. A poor ground may be worse than no ground at all, since it gives a false feeling of safety to those working around the equipment and also may result in ultimate loss of life or damage to the apparatus.

Accessibility for inspection and maintenance was well taken care of in this 440-volt installation.

The method of mounting the circuit breakers, buses, and so on, on the pipe framework is well shown here.



AUXILIARIES

Protective and Alarm Relays.—Relays supplied in connection with the proper operation (for tripping, sounding an alarm, etc.) of oil circuit breakers should be wired up in accordance with the connection diagrams furnished by the manufacturer. As these relays are rather delicate mechanisms, because of the close regulation they provide, frequent inspection of the relays should be made. Operating tests under actual conditions are necessary and both mechanical and electrical performances should be noted. The relays must be kept free from dust and dirt and the settings should be inspected periodically to prevent the operator from abusing the equipment by defeating some of the protective or operating features of the apparatus.

Relays should be adjusted only

within limits determined by the manufacturer. If observance of this does not provide operation essential to the application, the manufacturer should be consulted. The instructions supplied with the relays should be carefully followed.

Dashpots.—Oil dashpots should be examined periodically to see that they are properly filled with suitable oil, in accordance with the manufacturer's instructions. By-passes and check valves should be examined and cleared. Dirty oil should be replaced. Substitution of oils other than specified or furnished by the manufacturer should be avoided and only in extreme emergencies should this be done, and then only by authorized and competent persons. If it is necessary to supply oil temporarily for dashpots, oil should be chosen that will not become thick at the lowest temperature to which it will be subjected. Ice machine oil is suitable for this temporary use. Clean oil having the proper characteristics is essential for correct operation.

Tripping Coils (Automatic Operation).—Tripping coils used in the secondary of instrument current transformers are calibrated in secondary current values, which, when multiplied by the ratio of the transformer used, give the corresponding primary or line current values. The markings on the calibrating tubes represent the ampere values required to lift the plunger and trip the oil circuit breaker.

Tripping coils used in the secondary side of bushing current transformers are calibrated in primary current values and the markings on the calibrated tubes represent the secondary current values required to trip the breaker.

Undervoltage (Low Voltage) Release.—The proper holding and releasing action of undervoltage coils and mechanisms is dependent upon both mechanical adjustment and upon the application of the voltage (and frequency for alternating-current systems) specified on the nameplate. These devices should be inspected periodically to insure that their operation is not too violent, causing unnecessary strains to be placed on them.

Alternating-current release mechanisms should be examined periodically to see that the iron circuit is properly sealed and that the pole pieces are cleaned of rust and that they make a true, flat contact. Care on this point will prevent or lessen humming and failure of coils from excessive current due to open iron circuits.

When undervoltage devices are supplied for use in series with resistors, the connections should be carefully checked before full voltage is thrown across the operating coils.

After an oil circuit breaker has been installed with all mechanical and electrical connections completed, the following inspections and tests should be made:

(1) See that the breaker is properly set up and leveled on its supporting structure (panel, pipes, structural iron or steel frame, etc.)
(2) See that all bearing surfaces of the operating mechanism have been lubricated.
(3) Close the breaker slowly by hand (when it is dead) noting that the operating rod (or rods) and contacts are properly adjusted for correct alignment. Good contact should be made with the breaker closed.
(4) See that the tanks are filled with oil to the proper level (oil line or gauge.)
(5) Inspect all insulated wiring to see that no damage has resulted during the process of installing it.
(6) Test the wiring for possible grounds or short circuits.
(7) See that all current-carrying parts outside the oil tanks are correctly insulated in accordance with standard practice.
(8) See that all joints, whether bolted joints of copper bars, or soldered (or clamped) joints made with wires or cables, are made correctly.

Electrically Operated Oil Circuit Breakers.—Electrically operated oil circuit breakers should be operated manually (by hand) first, noting that all parts move freely and without binding. After careful inspection has shown all parts to be in proper working order during the manual operation, the breaker may be operated electrically at normal operating voltage.

The safety and successful functioning of connected apparatus depend upon the proper operation of the oil circuit breaker. Therefore, the circuit breaker must have regular, systematic care and inspection. The points that require especial attention during the inspection of oil circuit breakers are given above.

Points That Need Special Attention During Inspection of Oil Circuit Breakers

(1) Be sure the breaker and its mechanism are disconnected from all electric power, both high voltage and operating current, before inspecting or repairing.
(2) Inspect the operating mechanism periodically and lubricate all bearing surfaces of the mechanism regularly with a good quality of sperm.
(3) Keep the bearing surfaces of the toggles, rods and levers adequately oiled, as the mechanism cannot operate properly with "sticky" bearings.
(4) Keep the mechanism clean.
(5) Examine the contacts frequently. See that they are aligned and that contact surfaces bear with firm, uniform pressure. Replace badly pitted or burned contacts before they are burned away sufficiently to cause damage to other parts of the apparatus. If the contact surfaces are only roughened, they may be smoothed down with a fine file or fine emery cloth.
(6) Be sure the breaker is dead before lowering and removing the tank in order to examine the contacts.
(7) Be sure the breaker frame is well grounded.
(8) See that bolts, nuts, washers, cotter pins and all terminal connections are in place and tight.
(9) Inspect the bushing (insulator) supports, as the vibration due to the operation of the breaker may cause the bushings to move slightly and result in misalignment of contacts.
(10) Clean the bushings at regular intervals where abnormal conditions prevail, such as salt deposits, cement dust or acid fumes, to avoid flashovers as a result of the accumulation of foreign substances on their surfaces.
(11) See that the oil is kept at the proper level in the tank (or tanks) and that the proper dielectric strength of the oil is maintained. (See instructions on page 375 for testing oil.) Add new oil occasionally to replace the slight evaporation.
(12) Change or filter the oil every six months (or more often for heavy service).
(13) Filter the oil after successive openings under load (short-circuit, etc.) if it shows signs of carbonization, or if the dielectric strength is lowered because of dirt or suspended matter therein. Test the oil before replacing it in the tank. Carbonization is indicated by a flaky, black precipitate which floats in the oil when disturbed.
(14) Do not allow moisture to come in contact with the oil when filtering.
(15) Remove all oil once a year and thoroughly clean the tank (or tanks) and other parts (lining, etc.)

Electrically Operated Oil Circuit Breakers.—At all inspections the oil circuit breaker should be operated by hand to see that the mechanism works smoothly and correctly before it is operated electrically.

A breaker should not be operated electrically, with the oil tanks removed, any more than is absolutely necessary.

It is again strongly urged that the manufacturer's instructions for each oil circuit breaker be carefully read and followed.

It is recommended that sufficient spare parts be carried in stock to enable the operators of oil circuit breakers to promptly replace any worn, broken or damaged parts. It will be readily appreciated that a stock of parts reduces delays in service and saves time and expense. The manufacturer will advise the purchaser upon request.

Power Switching Equipment

Power switching equipment, as the term is used here, includes the following devices:

Bus supports
Single-pole, hook, stick-operated switches
Gang-operated disconnecting switches and mechanisms
Air-break, horn gap switches and mechanisms
Choke coils
Primary fusible cutouts and mountings
Fusible cutouts, resistors and mountings for potential transformers
Conductor fittings
Mounting structures

Handling

Upon arrival at destination, trucking and handling should be done with due regard to the fact that porcelain is used in practically all switching equipment and that it is easily broken.

All switching equipment should be properly stored to protect it.

Instructions for Assembly

As it is the manufacturer's desire that equipment give the most satisfactory results, instructions for assembly or drawings showing construction details should be followed.

Alignment.—Switching equipment should be carefully lined up on the supporting structure, care being taken to see that the structure surface on which the bases are mounted is flat and true, otherwise, the bases may be twisted when bolted to the structure. This will throw parts out of line and throw undue strain on the insulating units with resultant difficulties in operation and proper contact alignment.

Rigidity.—All switching equipment should be rigidly bolted in place and the supporting structure should be sufficiently stiff so that it will not spring or give to the extent that it interferes with proper operation of the equipment.

Rigging and Handling.—When handling switching equipment for erection, it is recommended that it be fully assembled and adjusted before placing it in position in so far as the size of the equipment will permit, as this will facilitate final adjustments.

Rigging which is used for erecting the equipment should be attached to the bases and not to the insulator units, contacts or operating parts which might be injured. All such parts should be kept clear of the rigging. When in place, adjustments should be made without weight or strain being placed on the insulators and current-carrying parts.

Personal Safety in Installation

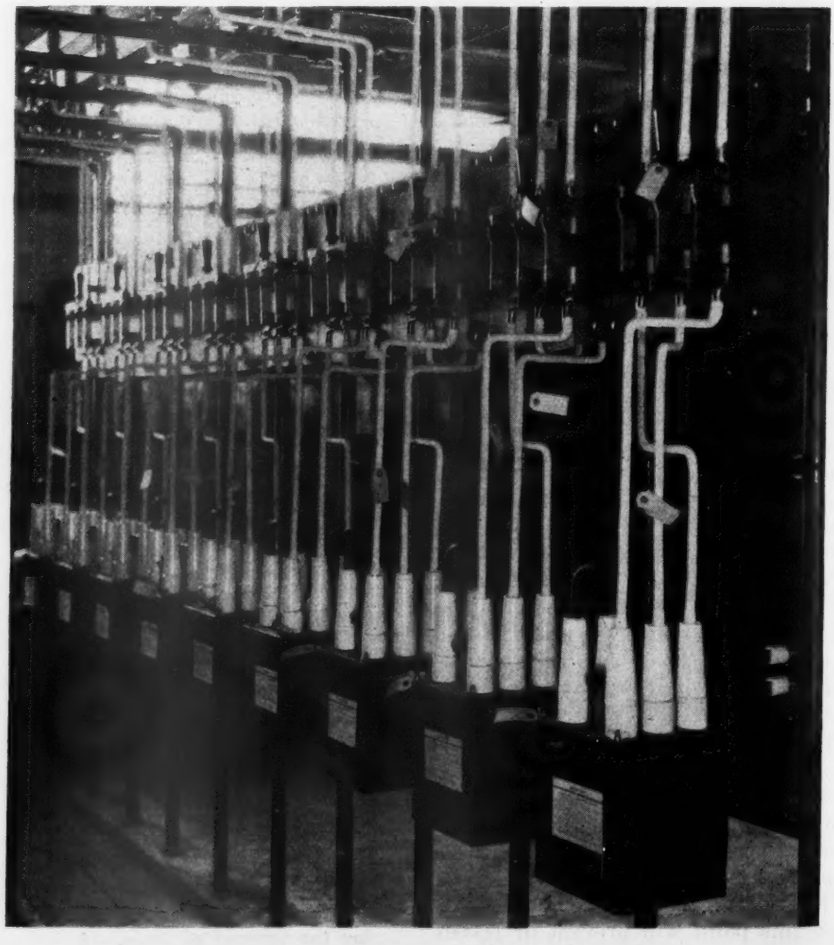
The usual Safety First precautions should be carefully followed.

When erecting switching equipment particular care should be given to the following:

(1) Make absolutely sure that the line on which men are working or erecting equipment is dead.
(2) Protect the workers adequately from adjacent live parts by barriers, screens, etc.
(3) Follow the National Electrical Safety Code as well as local requirements.

Erection of Switching Equipment

Adequate means for handling switching equipment should be used. Attention should be given to the strength of rigging and the use of sufficient scaffolding to permit of erecting the equipment without subjecting the insulators and mechanical parts to strains which might



Simplicity and neatness characterize this 440-volt, nine-panel, power switchboard, of which a rear view is shown here.

These oil switches operate at 440-volts, three-phase.

distort and interfere with the successful operation of the equipment.

In addition to following the manufacturer's instructions carefully, it is recommended that the following points be considered.

Placing Switches.—Hook stick operated switches should be so placed that they are safely accessible for operation by means of the hook stick and without causing the operator to get too near live parts, lines, buses or insulators.

Cleaning Equipment.—After the switching equipment has been installed and connections completed, it should be carefully gone over and cleaned. Special attention should be given to cleaning the insulator units, contacts and moving parts.

Dead Ending.—Incoming or outgoing lines or conductors on which there is any appreciable strain should be provided with adequate, strain-type insulating supports in order to remove from the switching equipment any undue strains which might cause poor contact or throw the equipment out of proper alignment.

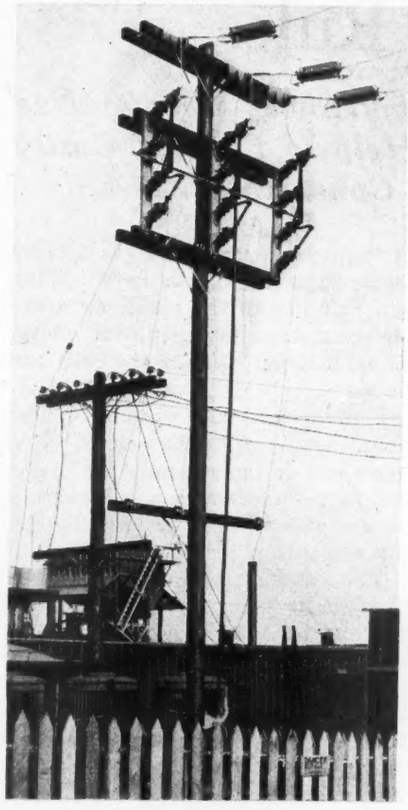
Lines should be anchored to the structure or nearby poles or towers. If lines are anchored to the tower, they should be arranged to give direct strains without tendency to twist the tower and throw the bases of equipment out of line.

If wood poles and wood cross arms are used for the lines, it is recommended in general that the insulators on steel structures to which such lines are connected be provided with a higher factor of safety than the line insulators. Where steel poles or towers are used, this factor of safety is not so essential unless the station is subjected to fumes, smoke or other dirt.

Conductors.—It is important that bus arrangements which make use of strain-type insulation be rigidly installed. Owing to the physical dimensions of the structure, such conductors should be under sufficient strain to keep them from excessive swaying.

Conductors should be run as nearly as possible in straight lines and should be supported sufficiently to withstand the mechanical load and magnetic stresses.

Expansion and contraction of conductors due to temperature changes may develop heavy stresses on the supporting insulators and connected equipment. In long, heavy bus structures care should, therefore, be taken to see that means are provided to allow for expansion. The importance of this question depends upon the length of conductors and the possible temperature variation.



This does not look like a temporary installation, but it is.

Oftentimes "temporary installation" is only another term for slip-shod workmanship, with little or no planning back of it. This is not true of the installation shown above. The incoming lines carry three-phase power at 25,000 volts. As will be noted the disconnecting switches, which are provided with high-tension fuses, are controlled by the lever on the pole, just above the fence. Suspension-type choke coils were used to good advantage here.

The cantilever strength of conductor supports is becoming an increasingly important factor due to the weight of buses and electro-magnetic stresses under short-circuit. For this reason the height of bus supports should be kept down to a minimum consistent with the full flashover value of the porcelain body.

On alternating-current conductors the conductor clamps should not form a closed magnetic circuit around the conductor.

Switching Equipment Connections.—Contacts should be clean and smooth. Excess strains should be carried by auxiliary supports. Soldered connections should be carefully made to insure that the joint is completely filled with solder. It is recommended that soldered connections be relieved from undue mechanical strains.

Ground Connections.—All switching equipment should be grounded in accordance with the best accepted practice. (See National Electrical Safety Code requirements for grounding.)

Steel frames or structures for supporting equipment should be adequately grounded at several points to guard against poor joints.

All grounds for the switching equipment and structure should be independent of the lightning arrester ground.

Fusible Cutouts.—Primary fusible cutouts of the expulsion type should be provided with good clearance in the direction in which they blow and facilities should be provided for operating them without requiring the operator to get near the expulsion end.

Mounting Structure

Location.—Consideration should be given to the location of the structure relative to the question of smoke, dirt and fumes. It is desirable to locate the structure in a place as free from such conditions as possible as they may cause rapid deterioration of the conductors and contact joints, corrode parts, cause them to make imperfect contact and reduce the flashover value of the insulation.

Foundations.—The foundations should be carefully prepared and of sufficient size, depth and strength to adequately withstand all possible strains which the structure may be required to meet.

Plumbing and Alignment.—It is important that the structure be carefully plumbed and aligned, otherwise the equipment may not line up properly and in addition to bad appearance might give difficulties in mounting and operating.

Inspection

It is important that after installation and before placing in service the mounting structures and equipment be carefully inspected and checked with the manufacturer's drawings. The following are suggested as details which should be carefully gone over:

(1) Examine insulator units.
(2) Examine contacts.
(3) Examine switch locks.
(4) Examine mechanisms, with reference to operation, lubrication, and

(*Please turn to page 402*)

Here Are Some

Practical Pointers And Winding Rules

For D. C. Armatures That Show How to Use Winding Data and Will Help to Prevent Costly Mistakes in Rewinding and Connecting

By A. C. ROE

Renewal Parts Engineering Dept., Homewood (Pa.) Works, Westinghouse Electric & Mfg. Co.

and

D. H. BRAYMER

Consulting Editor, Industrial Engineer,

THE PRACTICAL use that can be made of the forms for taking and recording winding data, which were discussed in the June and July issues of INDUSTRIAL ENGINEER, is shown in this article and others that will appear in later issues. Details are given for starting and winding lap- and wave-wound armatures and certain practical rules are presented that will help the winder to prevent mistakes and make sure that the proper coil layouts and connections to the commutator are used for different numbers of slots and commutator bars, with different numbers of poles in the motor.

THIS article supplements those that appeared in the June and July issues, dealing with the methods of taking and recording rewinding data, and the forms that are convenient to use in this connection. Actual illustrations are given to show how to apply the data recorded to a particular job in the shop. References are made to illustrations that appeared in the June and July issues and it will be well to have these available when reading this article.

WINDING RULES THAT GOVERN LAP WINDINGS

A lap winding can have any number of bars, even or odd, but as a general rule the total number of bars selected must make possible a balanced winding; that is, there should be an equal number of coils per circuit or leg, particularly on cross-connected armatures; this means the total number of bars will be a multiple of the number of poles, in cases where a balanced winding is desired. There are a number of cases, however, where an odd number of coils can be used, so that there is no set rule as to the number of bars and coils that can be connected up into a lap winding.

In a lap winding, left-hand or right-hand coils do not affect the polarity or rotation of the machine. A left-hand coil is one in which the top half of the coil is on the left-hand side when the coil is in place on the armature and the observer faces the commutator end of the armature. The coils shown in the data forms, Figs. 4 *A* and 5 *A* (July issue, page 335) are left-hand coils. A right-hand coil (Fig. 5 *B*, July issue, page 335) is one in which the top half lies to the right when the observer stands as mentioned above. Thus, in a lap winding the coils can be made right or left without affecting the polarity or rotation. The only way in which the polarity of a generator or the rotation of a motor can be reversed, with a lap winding on the armature, is by crossing the top and bottom leads of each coil.

The above statements can be checked by referring to Figs. 1 *A*, 1 *B* and 1 *C*. Fig. 1 *A* shows part of a left-hand lap winding. Coil *A* connects to bars *1* and *2*; coil *B* to bars *2* and *3*, etc. If it is assumed that a positive brush is in contact with bars *3* and *4*, then coil *C* (marked with a cross) will be short-circuited by the brush and will not carry any working current at all.

In a lap winding there are as many circuits or current paths as there are poles, and also as many brush positions as there are poles. From each positive brush, therefore, there must be two paths through the winding to the negative brushes. In Fig. 1 *A* one path starts at bar *4* to the left, then goes to slot *4* as shown by the arrow, then to slot *10*, to bar *5*, to slot *5*, to slot *11* and to bar *6*. The arrows on slots *4* and *5*

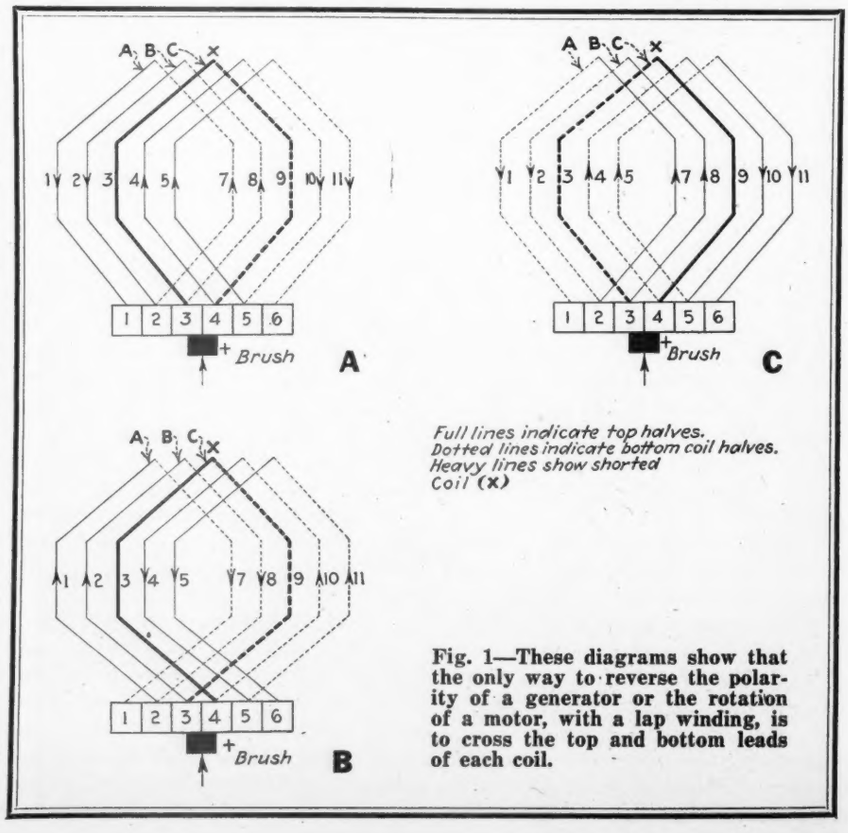

A B C X
1 2 3 4 5 7 8 9 10 11
1 2 3 4 5 6
+ Brush
A
A B C X
1 2 3 4 5 7 8 9 10 11
1 2 3 4 5 6
+ Brush
C
A B C X
1 2 3 4 5 7 8 9 10 11
1 2 3 4 5 6
+ Brush
B
Full lines indicate top halves.
Dotted lines indicate bottom coil halves.
Heavy lines show shorted Coil (X)

Fig. 1—These diagrams show that the only way to reverse the polarity of a generator or the rotation of a motor, with a lap winding, is to cross the top and bottom leads of each coil.

point up, and on slots *10* and *11* the arrows point down. The second path starts at bar *3*, goes up through slot *8*, down through slot *2* to bar *2*, up through slot *7*, and down through slot *1* to bar *1*. The arrows on slots *1* and *2* point down, while the arrows on slots *7* and *8* point up. The short-circuited coil forms the dividing line between the up arrows on slots and the down arrows on slots.

By comparing Fig. 1 *B*, which shows a right-hand winding, with Fig. 1 *A* it will be noticed that coil *C* is shorted, and that the arrows on slots *1* and *2*, *4* and *5*, *7* and *8*, *10* and *11*, in Figs. 1 *A* and 1 *B* are in the same direction. Hence, a left-hand or right-hand coil does not affect the rotation or polarity.

Next, refer to Fig. 1 *C*, which is practically the same as Fig. 1 *A*, except that the leads have been crossed; that is, the top lead of coil *A*, Fig. 1 *C*, connects to bar *2* and the bottom lead to bar *1*, which is just the reverse of Fig. 1 *A*, in which the top lead of coil *A* connects to bar *1* and the bottom lead to bar *2*. Then with the brush in the same position as used in Figs. 1 *A* and 1 *B*, coil *C* will be shorted as before, but the right-hand path starts at bar *4* and goes to the right, up through slot *10*, down through slot *4* to bar *5*, up through slot *11* and down slot *5* to bar *6*. The left-hand path starts at bar *3*, goes to the left, up through slot *2*, down slot *8* to bar *2*, up slot *1* and down slot *7* to bar *1*. By comparing the directions of the arrows in the slots of Fig. 1 *C*, with the directions of arrows on the slots of Figs. 1 *A* and 1 *B*, it will be found that slots *1* and *2*, *10* and *11*, have up arrows in Fig. 1 *C*, while the same slots in Figs. 1 *A* and 1 *B* have down arrows. Slots *4* and *5*, *7* and *8* of Fig. 1 *C* have down arrows while the same slots in Figs. 1 *A* and 1 *B* have up arrows. In a motor with the same field coil polarity, the direction of rotation of the armature in Figs. 1 *A* and 1 *B* would be opposite to that of the armature shown in Fig. 1 *C*. In a generator the direction of rotation would be the same, but the currents induced in the armature would change the polarity of the brushes.

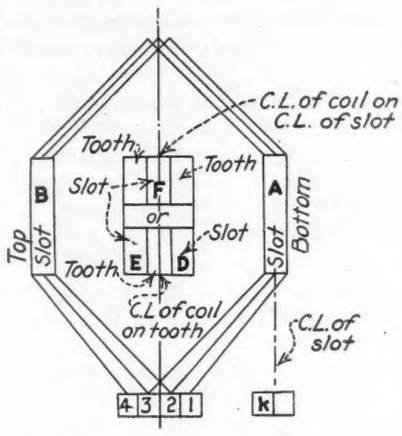


Fig. 2—Here is a diagram that can be used under any condition encountered in laying out coils for a lap winding.

Two arrangements of slots are shown. The top arrangement is for use when the center line of the coil falls in the center of a slot, while the lower arrangement is used when the center line of the coil falls on the center of a tooth. The relative position of the center line of the coil to the center line of the mica, bar, slot and tooth, under different conditions, is given in the rules in the next column on this page.

The following rules refer to the relative position of the center line of the coils, to the center line of the mica, bar, slot and tooth.

(1) In Fig. 2 when the number of coils per cell is odd, one, three, five, etc., and the coil pitch is one and an even number as 1-and-8, 1-and-10, etc., the center line of the coil will fall on the center line of the tooth and the mica.

(2) With the coil pitch one and an even number, and an even number of coils per cell, the center line of the coil will fall on the center line of a tooth and bar.

(3) With the coil pitch one and an odd number as 1-and-9, 1-and-11, etc., and the coils per cell an odd number, the center line of the coil will fall on the center line of a slot and mica.

(4) With the coil pitch one and an odd number, and the coils per cell an even number, the center line of the coil will fall on the center line of a slot and bar.

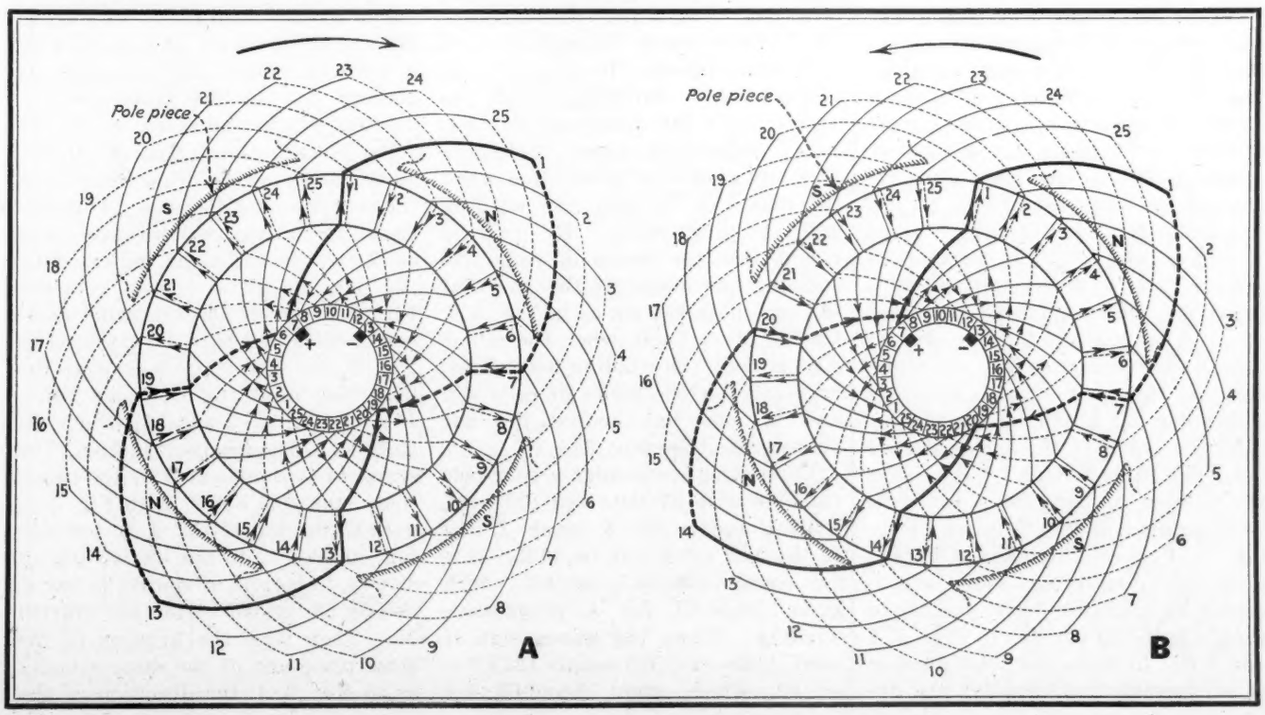


Fig. 3—These diagrams show A, a four-pole, two-circuit, wave winding with retrogressive layout and connections and B, a four-pole, two-circuit, wave winding with progressive layout and connections.

By tracing through a series of coils in diagram *A*, it will be noticed that the series ends one bar behind the bar on which the series started, giving what is termed a retrogressive winding. On the other hand, each series of coils in diagram *B* ends one bar ahead of the bar on which that series started, thus giving a progressive winding.

(5) With the coil pitch one and an odd number, the center line of the coil will fall on a slot, and with the coil pitch one and an even number the center line will fall on a tooth.

With the above rules in mind, slots *D*, *E*, *F*, of Fig 2 can be located as follows: Call slot *A*, No. 1 and express the coil pitch *S* in slots, as 1-and-10, or *S* equals 9. Then, when $(S+2)\div 2$ equals a whole number, this will be the number of slot *E*. For example, with a pitch of 1-and-13, *S* equals 12 and $(S+2)\div 2$ equals $14\div 2=7$, or *E* equals slot 7. When $(S+2)\div 2$ results in a fraction, the whole number will be slot *D* and by adding the fraction ½ to the answer obtained above, slot *F* will be located. For example, with a coil pitch of 1-and-12, *S* equals 11, and *D* equals $(11+2)\div 2$, or 6½. Slot *D* is then 6, and *F* equals 6½+½ or 7. The following formula may be used for locating bar *K*:

$K=Y-[\,(\text{coils per cell}\div 2)\times(\text{coil pitch}-2)\,]$, where *Y* equals the total number of bars. For example, if there are 28 slots and 84 bars, coil pitch 1-and-7, $K=84-[\,(3\div 2)\times(7-2)\,]=76.5$, or *K* equals 76. When *K* comes out a whole number and a fraction, drop the fraction and use the whole number.

The above rules cover the majority of cases of lap windings and the instructions given later will enable the reader to check and lay out any special winding.

Winding Rules That Apply to Wave Windings

There is a fundamental principle that applies to the number of bars that can be used in a wave winding: namely, the total number of bars for a single-series (wave) winding must satisfy the formula $L=(B\pm 1)\div P$, where *L* equals the lead pitch expressed in bars, as 49, 50, etc., *B* equals the total number of bars, and *P* equals one-half the number of poles. This formula requires that a group of coils connected in series, equal to one-half the total number of poles, shall encircle the armature, and that this series of coils must end either one bar ahead, or one bar behind the bar that the series started on. (See Figs. 3 *A* and 3 *B*.) Thus the number of bars for a four-pole winding must always be an odd number, or if an even number of bars is used, one or more bars must be connected by a long or short jumper to form a half-idle bar (as in Figs. 4 *A* and 4 *B*), to make the total number of bars satisfy the formula. On six-pole machines the number of bars can be odd or even, but each case must satisfy the formula. On eight-pole windings the number of bars must be odd, etc.

The above formula furnishes the basis for working out wave windings as applied to direct-current armatures. Details will, therefore, be given to describe its practical application. For a four-pole machine the formula can be changed to read, lead pitch equals $(B-1)\times 0.5$, for retrogressive windings, and to $(B+1)\times 0.5$ for progressive windings. From the above it follows (for any number of poles) that when the plus sign is used, the winding will be progressive. By this is meant that the series of coils will end one bar ahead of the bar that the series started on, as in Fig. 3 *B*. On the other hand, when the minus sign is used, the winding will be retrogressive or the series of coils will end up one bar behind the bar started on. (See Fig. 3 *A*.)

For example, consider a four-pole machine with 25 slots and 125 bars. Then *B* equals 125, *P* equals 2, and *L*, the lead pitch, can be $(125+1)\times 0.5$ equals 126×0.5, or 63, which gives 1-and-64 for a progressive winding. When the minus sign is used, $(125-1)\times 0.5$ equals 124×0.5, or 62, which gives 1-and-63 for a so-called retrogressive winding.

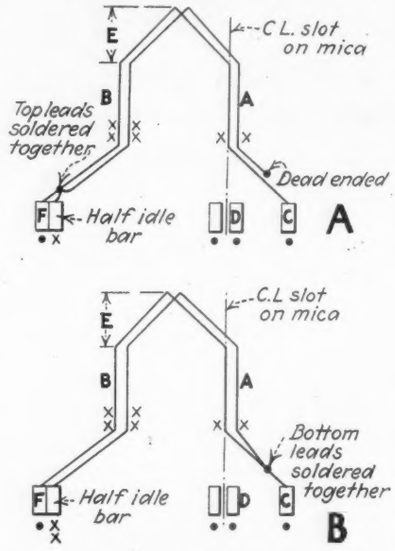


Fig. 4—Two methods of making a half-idle bar connection.

In diagram *A* two top leads are soldered together and two leads brought out from the junction to the two commutator bars, as shown. The bottom lead of the right-hand single coil is dead-ended. In diagram *B* the bottom lead of the right-hand single coil is soldered to the bottom lead of the second single coil. One lead from this junction is brought out to bar *C*, while the two top leads are brought out to two bars, as shown at the left.

This brings out an important feature of the wave winding on a four-pole machine; that is, when a given number of bars satisfies the above formula, then a retrogressive or progressive winding can be used as desired. This applies only to four-pole windings, however, since with six, eight, etc. poles, the type of winding depends upon whether one is to be added or subtracted from the given number of bars to make it close up. This is important because with a wave winding, changing from a retrogressive to a progressive winding, or vice versa, will reverse the direction of rotation in a motor and change the polarity of the brushes on a generator.

Figs. 3 *A* and 3 *B* are shown to illustrate this important fact. To simplify things, 25 bars and slots have been used. The coil pitch is 1-and-7 in both cases, and a left-hand winding is used. The pole-pieces for a four-pole machine are shown in dotted lines. With 25 bars and four poles, the lead pitch for a retrogressive winding should be $(25-1)\times 0.5=12$, or 1-and-13. The winding shown in Fig. 3 *A* is laid out with this lead pitch of 1-and-13. One series of coils is shown with heavy lines (coils *1* and *13*) the series starting on bar *7*, to slot *1*, slot *7*, to bar *19*, to top slot *13*, bottom slot *19*, to bar *6*, or one bar behind the one started on. Next, assume that this armature winding is used in a motor and that the brushes are in contact with bars *7* and *13*, as shown. With bar *7* in contact with a positive brush, the direction of current flow in the armature conductors will be indicated by the arrows in each slot. Slots *21* to *25*, show the arrows pointing away from the center of the diagram. This will cause the armature to rotate in a clockwise direction, as indicated by the larger arrow. Now consider Fig. 3 *B* which has the same number of slots and bars as was used in Fig. 3 *A*. But, Fig. 3 *B* uses the long lead pitch, or *L* equals $(25+1)\times 0.5=13$, or 1-and-14, which results in a progressive winding. The series of coils indicated by the heavy lines, starts on bar *7*, as in Fig. 3 *A*, goes to the top of slot *1*, to the bottom of slot *7*, to bar *20*, to top of slot *14*, to bottom of slot *20*, to bar *8*, or one bar ahead of the one started on. Then with the brushes in the same place and of the same polarity as in Fig. 3 *A*, the direction of the

current in slots *21* to *25*, will be opposite to what it was in Fig. 3 *A*, and with the same field coil polarity, the armature in Fig. 3 *B* will rotate in a counter-clockwise direction as indicated by the large arrow.

The reason for this reversal can be understood if we start at bar *7* in Fig. 3 *A* and follow one path through the armature to the negative brush in contact with bar *13*, putting direction arrows in each slot as we pass through. Consider the top half of the coil in slot *1* as the starting point and dividing line; then the current path is, bar *7*, up slot *1*, down slot *7*, bar *19*, up slot *13*, down slot *19*, bar *6* and up slot *25*. Note that we now pass up through a slot to the left of the first slot passed through for the beginning of the second series. We continue down slot *6*, bar *18*, up slot *12*, down slot *18* to bar *5*, then up slot *24*, or we are picking up a slot to the left at the end of each series, until we finally end up on bar *13*. Next, compare Fig. 3 *A* with 3 *B*. Starting on bar *7*, we pass up through slot *1* as before and down slot *7*, to bar *20*, up slot *14*, down slot *20* to bar *8*. Note that we have advanced one bar and slot to the right with the pick-up of the second coil, and that from bar *8* we pass up through slot *2*, or to the right of slot *1*. This will continue until we reach bar *13*. Compare the current direction in slot *2* in both illustrations, Figs. 3 *A* and 3 *B*. It is the overlapping of the series that changes the current flow and from the above it is obvious that in changing from a progressive to a retrogressive winding or vice versa, regardless of the number of poles, the direction of rotation in a motor will be reversed, and in a generator the polarity of the brushes will be reversed.

What really happens in a generator, when the winding is changed, can be explained as follows: The direction of rotation is fixed and with a shunt- or compound-wound, self-excited generator, with long or short shunt connection, the field circuit forms a closed circuit regardless of whether the line switch is closed or open. Now, the field poles of any generator retain a certain amount of magnetism, or they act as permanent magnets, so that when the generator armature starts to revolve, and the field switch is closed, the armature conductors cut the lines of force due to the residual magnetism and a voltage is induced in the armature conductors, causing a current to flow around through the field coils and increase the field strength. This cycle keeps up until full-load voltage is reached. When the armature winding has been changed, the direction of current under any one pole will be the same, but the brush sign will be changed and when the generator is started, the first slight voltage generated due to residual magnetism will tend to reverse the field coil polarity and weaken the field; hence the generator will not be able to pick up. The only way to make the machine pick up would be to reverse the field connections which would necessitate flashing; that is, putting current through the fields from an outside source, to create a residual flux of the right polarity and enable the machine to pick up. Or the armature leads can be reversed and if caught in time, reversing the armature leads will in most cases eliminate the necessity of flashing the field. On the other hand, if the machine is separately excited it will pick up its voltage, but the busbar polarity will be reversed, which in a battery charging outfit would cause considerable trouble.

To point out some other effects of changing windings, Figs. 5 *A* to 5 *F* are shown.

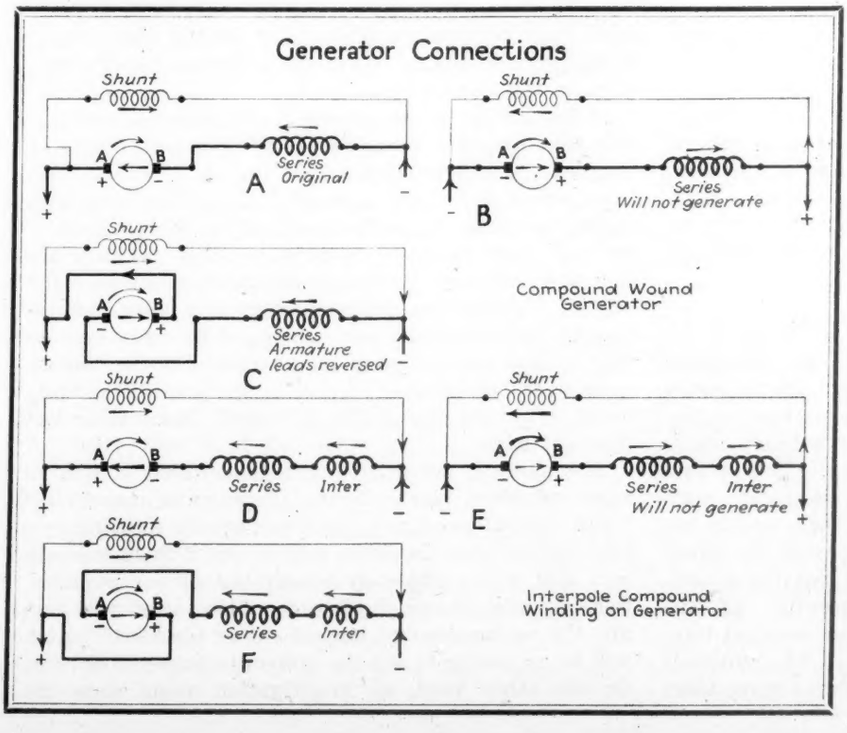
Fig. 5 *A* shows the armature and field circuit of a compound-wound generator. The directions of the arrows on the shunt and series fields are opposite, but this can be accepted as standard, as it makes the diagram straight lines. In a generator diagram, then, when the shunt and series arrows point in the opposite directions, we will call this standard. The direction of current through the armature is indicated by the arrow inside the circle, while the curved arrow indicates the direction of rotation. Next, consider Fig. 5 *B*, which shows the current flow in the same machine, with the armature winding changed. Note that brush *B* is positive, which changes the polarity of the shunt and series coils, but both coils still assist each other. The generator shown in Fig. 5 *B* will not pick up as already explained. Fig 5 *C* shows the simplest method of correcting the mistake. In this case the armature leads have been interchanged.

Fig. 5 *D* shows a compound-wound generator with interpoles. Note that the interpole coils are shown on the same side of the armature with the series coils, which results in a lower difference of potential between these two sets of coils, and reduces the chance of flashover between them. Fig. 5 *E* shows the same machine with the armature changed. This machine will not pick up until the connections are changed as in Fig. 5 *F*. Note that the series and interpole coils are handled as a unit.

Next, we will consider a motor.

(*Please turn to page 402*)

Fig. 5—These diagrams show correct and incorrect connections for compound-wound generators.



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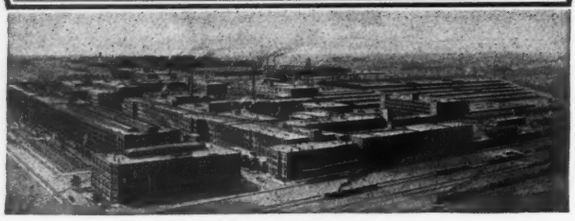

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Associate Editor

Chicago, August, 1925

Plant Savings Depend on Vision as Well as Volume

RECENTLY an executive in a small industrial plant lamented, during a plant inspection trip with one of the editors, the inability of a small plant to adopt money-saving ideas from a large one. The lack of vision of this plant executive was well illustrated by his actions on this trip. He was very much interested in the big savings made with a large crane, an extensive conveyor system, and other big units which were far beyond the capacity of his plant. On the other hand the type of tote boxes used and the methods of handling, piling and storing them, the inspection routine in connection with motors and other equipment, and the details of handling other problems common to his as well as practically all plants, were dismissed as too commonplace even to look at. As a result he did not carry away one worth-while idea.

This executive believes that savings and methods are inseparably connected with large, quantity production. A big volume of savings is, of course, related to quantity production, but the possibilities of making savings in industrial work are no more dependent upon volume than is the possession of a savings account at the bank dependent upon the amount of salary earned. Both depend upon the willingness to save and the ability to see opportunities for saving. The savings may be small, but they are possible.

What Happens When an Induction Motor Starts

WHEN an induction motor starts something happens besides the drawing of a heavy starting current. This is no news to electrical engineers, but it has taken a long time for them to find out and agree on just what it is that goes on in the windings of an induction motor during the starting period.

J. T. Rylander, at a recent convention of the A. I. E. E., has come forward and told us about at least three things that happen, as follows: (1) The windings separate between phases. (2) The windings move away from the rotor and toward the stator. (3) The top and bottom layers of coils draw together.

This is a most intelligent explanation of some of the mysterious grounds and short-circuits that develop in a winding and are, in most cases, laid at the door of some armature winder who got in a hurry and pounded too hard with his mallet and drift. The mallet and drift, when roughly handled, provide a sure way to start a weak spot in a winding when the slot space is crowded and wedges are used, but it is gratifying to know that at least one well-informed engineer is willing to admit that improper use of starting equipment is just as bad in its effect on the motor winding as the roughly-handled mallet and narrow drift.

Lest we be misunderstood, it is important to say here that Mr. Rylander in his A. I. E. E. discussion was attempting to prove that the windings of induction motors can be so braced and insulated as to stand the mechanical strains of even full-voltage starting. In this he went a long way, but we believe it will take a long time and be a hard job to make, at a reasonable cost, a large induction motor that will be free from operating troubles when used without a suitable starting device that will limit the current rush at starting and the mechanical strains on its windings. Motors are bought to use and not to repair, and any device that will safeguard continuous performance is cheap operating insurance against those who are careless in their installation and upkeep. Modern motor starting devices furnish this insurance at low cost when good judgment and not merely price govern their selection and manner of installation.

More Light May Be the Key to More Production

WHEN the days are long, as they are now, and a minimum of artificial illumination is required, it is an easy matter to overlook the important part which the lighting system will begin to play within a month or two from now. The fact that such an oversight may be more expensive and serious than might be thought, is brought out in the article by Roy Palmer, on page 363 of this issue.

In this article he points out the interesting relationship that has been found to exist between intensity of illumination and production output. In the investigations which have been conducted in various industrial plants, increases of production ranging from 8.5 to 35 per cent were found to be possible when the illumination was increased to the proper value. Although the cost of illumination naturally increases with the intensity, this increased cost amounted in every case to only a small percentage of the payroll. In other words, a considerable increase in production was left as clear profit, after the cost of the increased illumination had been deducted.

The slowing down of production which occurs in most industrial plants during the summer months affords a good opportunity to check up the lighting system and see what should be done to put it in such condition that it can efficiently render the service required. Perhaps only a thorough cleaning of lamps and reflectors and the replacement of burned-out or blackened lamps, will be necessary to put the system in proper condition. On the other hand, an investigation might show the

need of a thorough revamping, in order to raise the level of illumination to its proper value.

In either case, the experience of many industrial plants shows that the returns will amply justify whatever expenditures are necessary.

Maintenance Today Will Save Repairs Tomorrow

TESTING important equipment so as to locate prospective failures should be the aim of every one responsible for maintenance work.

How this is being worked out at one plant may be of interest to others. As part of the regular maintenance work of a plant recently visited, the insulation resistance is measured on all vital or important motors and generators, at least once a month. These readings are recorded for comparison with readings taken later on.

The value of this practice was shown recently when the insulation resistance on the field of a synchronous motor began to fall below its usual value. It continued to get lower until a value of 600,000 ohms was reached, when an extensive investigation was decided upon. The individual coils on the poles were disconnected from each other and the trouble localized in one pole. The coil was removed from this pole and the insulation was found to be almost gone on the inside lower end.

If the machine had run much longer, undoubtedly a failure would have occurred, which would have interrupted production. As it was, the systematic tests gave warning of the approaching failure and permitted investigations and remedies to be applied on Sunday, when no production delay would occur, and there was time to do a good job.

This is just another example of how maintenance work can be made to yield big returns on the time and money spent on it. To paraphrase an old saying, a little bit of maintenance beforehand is generally worth a large amount of repair work—afterward.

What and Where Are Eye Hazards in Your Plant?

A REPORT which has recently been issued by The National Committee for the Prevention of Blindness, following an extensive study of eye hazards in industrial occupations, contains many statistics and facts that should be of interest to every plant executive. The toll which industry has taken in the way of injured or sightless eyes is shown by the following statement:

"Of the 100,000 blind persons in the United States approximately 15,000 are the industrial blind—persons who have lost their sight in the pursuit of industrial occupations. There is, in addition to the totally blind, a much larger number of men, women and children whose vision has been so impaired by the eye hazards of industry that they are handicapped throughout life. Both of these classes, the industrial blind and the workers whose vision has been seriously impaired by the hazards of other industrial environment, grow larger each year.

"The loss of 82 eyes in the presumably safe occupations of merchandising, farming, and textile manufacture, is further proof of the statement that serious eye accidents are likely to occur wherever men, women and children are employed. There is no such thing as a really non-hazardous occupation."

As an example of the important part that eye injuries play in the whole problem of industrial accidents the report cites the experience of a large shipbuilding company in whose dispensary 38 per cent of all injuries treated were eye injuries. More than 4,300 eye cases were treated in this company's dispensary in one year.

These facts would seem to constitute a severe indictment of industry, and serve to show that the prevention of eye injuries in industrial occupations is a problem that is worthy of, and should be given, the most serious attention. Carefully-kept records showing exactly where, how, when and why eye accidents occur will do much to show what changes should be made in equipment, methods, or processes in order to reduce the number of such accidents. Further, a careful study, from the standpoint of eye hazards, of the methods and equipment used in a plant may show where and how these hazards may be materially lessened.

Do Not Judge Suitability By the Price

BECAUSE a material is high priced does not necessarily mean that it is the most suitable for every industrial application. A case in point recently came to light in a large steel plant.

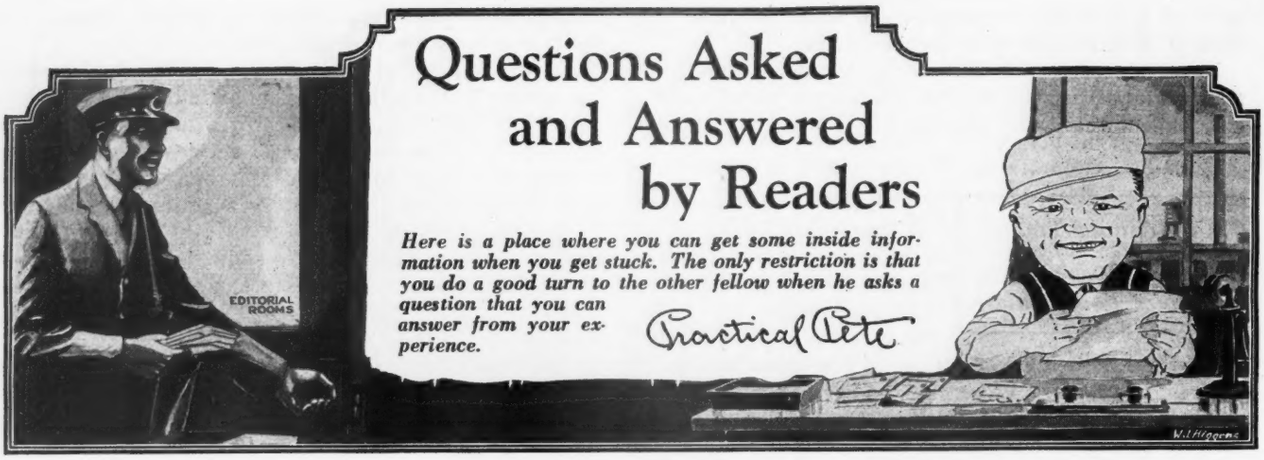
At this plant considerable bearing trouble was being experienced on certain equipment. Although the bearings which were originally furnished by the manufacturer of the equipment had shown satisfactory life, the bearing replacements made in the plant repair shop were not giving anywhere near satisfactory service.

Investigation showed that the babbitt metal that was being used was not suited for the service conditions under which these bearings had to operate. It was a good babbitt metal, but was being incorrectly applied. Substitution of a suitable grade of babbitt metal, which was melted and poured at the proper temperature, gave more satisfactory results. Incidentally, the correct grade of babbitt for this application cost less than one-third as much as that which had been formerly used.

This discovery stimulated other bearing investigations at this plant. It was found that everybody on the maintenance force was babbitting bearings. Since none of them knew much about babbitting, the results were poor indeed. Also, since more than one kind of babbitt is required for the various machines in the plant, and each of these babbitts has a different pouring temperature, it was somewhat a matter of chance as to whether the metal was poured at the right temperature.

The first step taken to correct these bearing troubles was to place all of the bearing work under one man, who either did the work himself or directly supervised it. The second step was the purchase of an electrically-heated babbitt pot with automatic temperature control, thereby insuring the correct pouring temperature. The third step was in taking additional pains in the selection of bearing metals that are particularly adapted to the service conditions. According to the superintendent of that plant, the results obtained have justified the additional expense involved many times over.

If you are looking for a place to cut maintenance costs it may be that your bearing troubles will stand a similar investigation.



Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Who Can Answer These?

Operating A.C. Demagnetizer on Direct Current.—Will some reader please tell me of a cheap and simple way of changing a 110-volt a.c. demagnetizer so that it can be operated on direct current at the same voltage?
Norristown, Pa. C. D. H.

* * * *

Changing D.C. Fan Motors for Operation on Alternating Current.—Our plant has recently been changed over from direct current to alternating current, 110 volts, 60 cycles, and I should like to know if there is any way of changing Westinghouse, 9-in. and 16-in. d.c. fans to operate on alternating current, as I do not wish to discard them if I can help it. One of these fans has the following nameplate data: Serial No. 1883821, style No. 321339, d.c. 100-125 volts. I shall appreciate your help.
Philadelphia, Pa. E. G. R.

* * * *

Method of Cleaning Skylights and Windows.—In our plant we have a serious problem in connection with the cleaning of skylights, transoms in monitor roofs and above the first floor, large windows with steel sash. I wish some readers would tell me what solutions they use for such cleaning, and describe any easily-constructed scaffolding or other method which they use to get to this large area of glass. This has been a very expensive and unsatisfactory procedure with us so far and I would like to know what others do.
Indianapolis, Ind. J. F. H.

* * * *

Contactors Will Not Close on Low Voltage.—We are having trouble with the contactors failing to close due to low voltage on one of our automatic control panels. The panel is fed from a 220-volt supply, but when the voltage drops considerably the operating coils of the contactors are not strong enough to close them, thereby leaving an open magnetic circuit which causes the coil to roast out. It is rather difficult to provide the correct voltage at this panel all of the time. Can any reader suggest something that I might do to the contactor coil that would enable it to take care of the low voltage condition?
Omaha, Neb. M. P.

* * * *

Trouble With Rewound Transformers.—I am having trouble with rewound G. E., type H. 5-kva., 2,300/220/110-volt transformers burning out within a few days after they have been placed in service. They break down between turns in the same layer, but do not break down to ground. In the primary I use No. 18 B. & S. gage single-cotton-enameled wire, impregnated with Westinghouse Amber baking varnish. I am using the same wire and varnish on motors with good results, but am wondering if I should use double-cotton-covered wire and some other varnish for the transformers. Do the transil oil and varnish combine to attack the enamel? These transformers are given a double voltage test for one hour before leaving the shop.
Ware Shoals, S. C. J. C.

Operating Two Slip-Ring Motors in Cascade.—I shall be very grateful if some reader will answer the following questions for me: (1) Will two slip-ring motors of the same make and type operate satisfactorily when connected in cascade and installed on the opposite ends of a turntable to drive separate tractors? (2) Will there be any difference in the speed of the two motors? If so, what will it amount to? (3) Can these motors be operated from one controller? If so, can they be used for reversing service when operated from one controller? (4) Must the shafts of the motors be rigidly coupled together?
Washington, Ind. C. L. O.

* * * *

Stopping Breakage of Gears.—On each battery of furnaces in our refinery there is a 7½-hp., 1,800-r.p.m., motor driving a device that clears the coke from the furnace. The motor is connected by a roller chain to a shaft driving a pinion meshing with a large double gear that drives the device. This device is subjected to very unusual loads at times, especially when it is about time for the furnace to be rebuilt. These loads are so heavy and come on so suddenly that the teeth are often broken off the bevel gear, which is made of cast iron. As it is rather expensive to replace these gears, I am wondering if our readers can suggest some device that I could put on this drive to disconnect it when the load becomes too great. Would a coupling having shear pins do the trick? How could I make such a coupling?
Tulsa, Okla. L. A. N.

Answers Received To Questions Asked

Emergency Excitation for Generators—For exciting our generators we have one motor-driven exciter which is normally in use. After the station has been completely shut down, we have one steam-turbine-driven exciter which is used for starting. Suppose that when we attempt to start up, the steam-driven exciter should break down. How could we excite our field? Could it be done by using several automobile storage batteries in series? For exciting our generator at no load, we require 60 amp. at 65 volts and it would be necessary for this supply to be on for approximately 10 min. Would it be practicable to use eleven 6-volt storage batteries in series for supplying this excitation? If so, what capacity should the storage batteries have? I shall appreciate any information that readers can give me on this problem.
Medicine Hat, Alta., Can. E. R. S.

Answering E. R. S. in the July issue, the fields can be excited only by the use of another exciter or an emergency battery. In one instance that came up in my experience, only a motor-driven exciter was used and an outside service was depended upon for energy when the station was completely shut down. Provision was made for an interruption in the outside service by putting an extension on the shaft of each generator unit, to which a small generator could be belted. A pulley was provided to fit the generator shaft extension. The small generator was mounted on a truck so that it could readily be moved about, and served its purpose very well. It is assumed that in E. R. S.'s case there are no electrically-operated oil circuit breakers in the station, requiring a battery which might be used as a source of current in emergency.

The fields could be excited by the use of a number of automobile batteries connected in series, but while it is practicable to do so this could not be recommended as a very satisfactory method. Whether the automobile batteries would handle a discharge rate of 60 amp. for ten minutes could be determined only by trying it, or by consulting the manufacturer of the batteries. Although many automobiles require between 50 and 100 amp. or more for starting the engine the duration of the discharge rarely exceeds one minute and is usually much less.

It is assumed, of course, that it is not desired to have a small gas- or gasoline-driven set, similar to the Delco or Kohler, available for this service. However, the ease of providing a shaft extension on which a pulley can be placed for driving the low-capacity exciter, as previously described, is, I believe, the simplest and most practical solution of this problem.

C. Otto von Dannenberg.
Designing Engineer,
Porter & Sanderson,
New York, N. Y.

* * * *

Trolley Wire Supports for Monorail Crane—I have a monorail crane running on an I-beam, which has to travel around two rather sharp bends, and wish that someone would give me his experience as to the best way of installing and supporting the two trolley wires that feed this crane. How should I support the wires where they go around the bends?
Barre, Vt. C. G.

In reply to the question by C. G. in the May issue, the use of trolley wires around curves on crane tracks is very troublesome. We have found that the tee bar system is by far the best to use under these conditions.

If 1¼-in. tee bar is used it can be bent cold to fit almost any bend or angle that may be required. The tee bars should be held in place by

1½-in. by ½-in. angles clamped to the top of the I-beam.

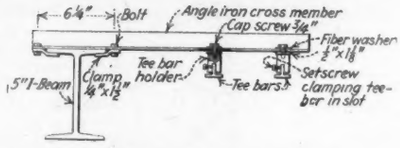
At the proper distance apart, equal to the distance between the collector shoes on the hoist, two ¾-in. holes should be drilled in each angle. Into these holes a piece of fiber tubing ¾ in. in diameter with a ½-in. hole should be placed, and cut off flush with both sides of the angle. On the same side of the angle, two 7/16-in. holes should be drilled for supporting the clamps by which the angle cross-member is fastened to the I-beam. For a 5-in. beam we drill these holes 6¼ in. apart. For the clamps we use a piece of steel ¼ in. thick and 1½ in. long. By placing a ¼-in. offset in this piece, drilling a 7/16-in. hole in the end and placing this clamp against the underside of the top of the I-beam, and bolting to the crossarm, a very rugged support can be made.

For the tee bar holder a piece of steel 1 in. square and 1½ in. long is used; a hole is drilled in one end and tapped for a ½-in. capscrew. In the other end a slot is cut ¼ in. wide and ¾ in. deep. In one side, opposite the slot, a hole is drilled and tapped for a ⅜-in. setscrew for holding the tee bar.

When mounting the tee bar support to the crossarm a fiber washer ⅛ in. thick and 1⅛ in. in diameter with a ½-in. hole in the center, is placed between the tee bar support and the crossarm. Another washer of the same size is placed on top of the angle-iron crossarm. A ½-in. capscrew with a flat iron washer is then screwed through the washers, bushing, and into the tee bar support; this prevents any danger of grounding. This method of supporting tee bars indoors has proven a success with us; for outdoor service we use a porcelain support in the same way.

For collecting the power from the tee bar we use a shoe made by the Shepard Electric Crane & Hoist Co., Montour Falls, N. Y. These shoes are designed to take care of any uneven joints and also any side motion caused by swinging loads, and to keep a constant pressure against the tee bar. On our hoists which operate on very sharp curves we use a wider shoe; this gives us greater contact when the hoist first starts to make the curve.

The operation of a medium-sized hoist, with a capacity ranging from 2 to 6 tons, operated on curved I-beams continuously, means a very heavy maintenance cost, owing to the fact that as soon as the loaded hoist enters on the curve it must change the direction of the load. This causes a side strain on the hoist, causing the wheels to bind againt one side of the I-beam. In a short time this cuts the flange of the hoist wheels to such an extent that if the wheels are not changed at regular intervals climbing of the wheels on the I-beams will be experienced on the curves, thereby permitting the opposite wheels to wedge against the I-beam flange and stick, making it necessary to rock the hoist back and forth on the beam. At the same time, the I-beam cuts very fast, shortening the life of new wheels and in due time replacing of the beam is required, which is a costly operation.



This shows how the tee bars are supported from a crossarm mounted on top of the I-beam.

In view of this we have adopted the plan of fastening a 16-lb. rail to the lower flange of the I-beam by means of the Shepard rail clamp, which does not require any drilling of the I-beam for supporting the rail. When replacements are necessary it is much cheaper to change a rail than a curved I-beam. Also, as the rail has a much wider surface bearing against the flange of the wheel on curves, the life of the wheel is prolonged.

At present we are operating several hoists on the above system 24 hr. a day, under severe duty, including side lifts and overloads. The delays and repairs are very low, considering the service we get from the hoists.

I hope that the facts and suggestions given above will be of help to C. G.

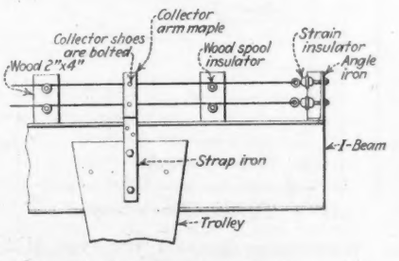
Chief Electrician, N. H. CASE.
Wyckoff Drawn Steel Co.,
Ambridge, Pa.

* * * *

In reply to the question by C. G. in the May issue, I would like to submit the following:

A few months ago I had occasion to install several Morris cranes of the monorail type which were equipped with Twin Flex cable having rubber insulation about 1 in. in diameter. This cable was looped from convenient switches up to the crane. This we found satisfactory, where the distance of travel was short. In one particular case, however, the crane had to travel a distance of about 200 ft. Such a length of cable was exceedingly cumbersome and always got in the way of things, twisting around workmen and trucks and breaking off at the motor connection, thus causing considerable delay and trouble.

To overcome this difficulty, we adopted a trolley wire system for this 200-ft. stretch of travel. At each end of the travel of the crane a support was erected at right angles to the crane travel. These supports were made of ½-in. by 6-in. angles. They were attached to the I-beam which carried the crane. On the side of the angle, which is at a right angle to the I-beam, two holes were drilled, one above the other, which hold the strain insulators to



Method of supporting trolley wire system for monorail-type crane.

which the trolley wires are attached. The trolley wires are of No. 4 hard-drawn copper. These wires were stretched between the two angles in such a position that they would be in line with the collector shoes on the trolley. To support the trolley wires and prevent them from sagging, wood insulators were placed beneath the trolley wires at convenient points. These wood insulators were shaped somewhat like a spool with flanges 2 in. in diameter, body 1½ in. in diameter and an overall length of 6 in. A hole suitable for a ½-in. bolt was drilled through the center of the insulator and countersunk at one end to take the head of the bolt. The wood insulators were fastened by means of long bolts to the uprights which are attached to the top of the I-beam, as is shown in the accompanying drawing.

At one part of the travel the I-beam had to be bent to meet the conditions under which it had to operate. This bend was about 6 in., running in this position for 15 ft., and reverting back to the same position. This difficulty was overcome by putting in longer bolts and placing wood fillers of the required length at the back of the insulator spools in that section.

The collector support is bolted to the trolley. The bottom part of the support is made of 2½-in. by ⅝-in. flat iron. To the top part of this flat iron is bolted a piece of maple 2½ in. wide by 1¼ in. thick and of the required length to suit the conditions. Two holes were drilled through the top part of the maple piece for the bolts carrying the collector shoes. The collector shoes have a deep groove which holds the trolley wires in position at all times. These grooves are placed slightly higher than the wood insulators, so that when the shoes pass the wood insulators they lift the wire above the insulators, permitting the shoes to clear the insulator. After the shoe has passed over the wood insulator, the wire settles back on the insulator. The bolts to which the collector shoes are attached have about 5 in. of thread so as to allow for adjusting the shoes to the proper position over the spools and for attaching the cables running to the hoist motor. The wooden part of the collector arm support is reinforced by a piece of ⅛-in. by 1-in. hoop iron over the top and extending about half-way down the side. The wood spool insulators are mounted on pieces of 2-in. by 4-in. wood which are bolted to the top of the I-beam and are placed at intervals of about 15 ft.

This trolley wire transmission eliminated all of the trouble that we had been having. It has been in successful operation for 12 months and there has not been a single delay on any of the cranes on which it was installed.

This performance must be considered exceptionally good when we consider the fact that the cranes are doing very heavy duty in the handling of car trucks, material and heavy dies for the hydraulic presses, and the like.

LACHLAN A. MCEWAN.

Maintenance Electrician,
Car Shops, Canadian National Railways,
Montreal, Can.

Answering C. G.'s question in the May issue, I use No. 8 trolley wire on the straight runs and ¼-in. by 1½-in. flat iron bent to the curvature of the I-beam on all curves and turns. The flat iron is supported on standard I-beam trolley wire supports. I believe that the use of this arrangement would satisfactorily overcome C. G.'s troubles.

Chief Electrician, EARLE N. DILLARD.
Booth-Kelly Co.,
Springfield, Ore.

* * * *

Replying to C. G. in the May issue, he will have to use a good many supports if he adheres to his policy of suspending trolley wires around sharp bends on a monorail crane system.

In place of trolley wire, I would suggest that he use at these bends and for 10 ft. or so on each side of them, ⅜- or ½- by 1½-in. iron flats, as they are called hereabouts. These are just flat iron ribbons and should be bent as desired and mounted edgewise on regular clamp-type insulators which, in turn, should be bolted to angle irons and the latter bolted or clamped to the top of the I-beam.

If preferred, flat copper strips could be used, although this is not necessary. In any case, where the strips and wire meet the strip should be cut back for a short distance in order that the wire may be brazed to the strip and then finished off, so that a smooth surface will be presented to the trolley wheel or collector.

Various schemes involving the use of clamps and other devices could be used to overcome the trouble C. G. describes, but I believe that the method outlined above is hard to beat, from the standpoints of simplicity and service.

Rome, N. Y. A. FIESS.

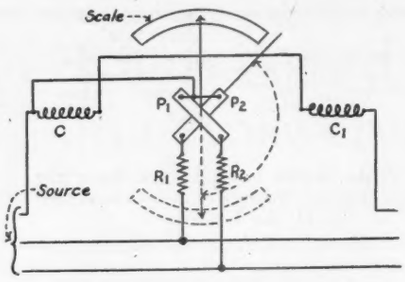
* * * *

Connecting Three-Phase Power Factor Meter—I should like to obtain the following information from some of the readers of INDUSTRIAL ENGINEER. (1) How may a three-phase power factor meter of General Electric make, be connected up for correct operation on either leading or lagging current when all of the polarity marks have been obliterated? (2) How may the circuits of the above meter be tested for continuity and zero setting of the pointer when it has been moved on the revolving shaft which supports it? (3) What would cause a shunt generator driven by an induction motor to build up slowly at the commutator and develop destructive arcing at the brushes after the load has been removed? What would be the remedy for such a condition? The armature is a single, parallel winding.

Saskatoon, Sask., Can. F. N. G.

In reply to the question by F. N. G. in a recent issue, the accompanying sketch shows the connection for a three phase instrument used on a balanced system.

C and C_1 are current coils in series on one leg of the system. P_1 and P_2 are potential coils connected across the other two legs of the line through the non-inductive resistance R_1 and R_2. In making the connections and checking for their correctness, the power factor must be known. If the needle drops to the bottom or dotted line scale, reverse the series connection. If the power factor is unity and the pointer takes a position to the right or to the left of center, reverse the potential leads. The circuits of the instrument



Internal and external connections of three-phase power factor meter.

may be tested for continuity with a lamp in series on a 110-volt circuit. If the pointer is loose or has been moved, connect the instrument to a circuit of 100 per cent power factor and place the pointer opposite the unity mark on the scale.

The character and range of the scale can also be changed by varying the angle between the potential coils.

With regard to the trouble which you are experiencing with a d. c. generator, the brushes are probably not set correctly in relation to the neutral point. Try changing the brushes either ahead or back a little at a time and see if it helps the sparking.

Chief Electrician, LEE F. DANN.
Donnacona Paper Co., Ltd.,
Donnacona, Que., Can.

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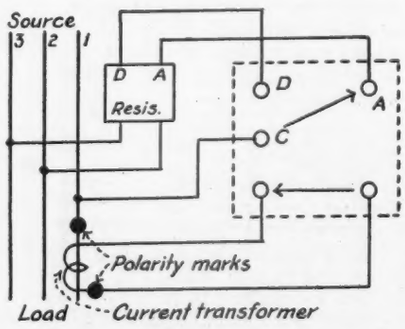
Referring to F. N. G.'s question in a late issue, (1) from the diagram it will be noted that the current from the generator is brought in at the right hand of the instrument when seen from the rear of the board. Should the connection be wrong the pointer will ride on one side of the scale in trying to turn 180 deg., and can be changed. If the pointer swings to the wrong side of the scale the potential leads should be interchanged between the resistor and the meter.

To check the connections of the meter short-circuit the current leads, at which time the pointer should go to the lag side of the scale regardless of whether the meter is indicating leading or lagging power factor.

(2) Unless one is thoroughly acquainted with the repair and operation of such a meter he should not attempt such repairs. It is much cheaper and better all around to have such work done at the factory by skilled operators.



Connection diagram for type H-2 power factor meter for circuits carrying 200 amp. or more.

(3) A weak field is apparently the cause of the generator trouble; I would also suggest that attention be given to the brush settings. Check the brush alignment and setting very carefully.

West Allis, Wis. EDWARD JAMES.

* * * *

How Long Will It Take to Erect These Towers?—I shall appreciate it very much if some of the readers of INDUSTRIAL ENGINEER can give me the amount of time in man-hours required to erect five steel transmission towers, 9 ft. by 15 ft. at the base and 60 ft. high. I should also like to know the time required to string three No. 3/0 stranded copper cables and one overhead ground wire a distance of 2,000 ft.

Appleton, Wis. M. P.

Answering M. P. in a recent issue, the question is rather indefinite as it gives no details as to the nature of the ground, present location of towers, whether the towers are already fabricated, whether foundations are already in, voltage, type of insulators, and so on. All of these points and many others would affect the cost of erecting the towers and putting the line in commission. Another point to consider is the previous experience of the erection gang in similar work, and the kinds of tools and equipment available. The erection of 2,000 ft. of line is quite different from erecting a line several miles long where the crew, even if they are comparatively inexperienced to begin with, will gain considerable proficiency in the work before many miles have been covered.

The best criterion for the cost of a job of this kind is reliable cost data secured from similar jobs. I have some figures covering the cost of a transmission line recently erected in the Middle West where unit labor cost would be the same as in M. P.'s territory. This was a 132-kv. line about 40 miles long. Double-circuit steel towers were used, having the approximate dimensions given by M. P. One circuit only was installed, using No. 3/0 steel-reinforced, aluminum conductor. The towers were assembled on the ground in a horizontal position and erected by means of a gin pole, block and tackle and a 2-ton tractor. A summary of the labor cost per mile of line, exclusive of trucks, freight, board, lodging, testing, tools, damages and miscellaneous was as follows:

(*a*)	Clearing	$ 244.00
(*b*)	Foundation	1,181.00
(*c*)	Assembling towers	311.00
(*d*)	Erecting towers	165.00
(*e*)	Stringing wire	130.00
(*f*)	Unloading and hauling	80.00
(*g*)	Engineering and supervision	240.00
	Total	$2,351.00

All of the above items, and especially item (*b*) were heavy because of the swampy nature of the ground. At this same rate a 2,000-ft. line would cost about $900 to put up, but it must be remembered that a small job cannot, as a rule, be handled as cheaply as a large one, on which everything is well organized.

In several other similar jobs the cost of erecting towers has gone as low as $95 per mile and from that

on up to $165, as given above. The labor cost of stringing wire has been found, under favorable conditions in this class of work, to go as low as $40 per mile of conductor, or $120 per mile of three-phase line. Under unfavorable conditions, it may go as high as $80 per mile of conductor.

Another example may be given of a 66-kv. line, 33 miles long, using steel poles 3 ft. 6 in. square at the base and 60 ft. high, carrying two No. 1/0 stranded copper circuits on suspension insulators. These poles were considerably smaller than those used in the first example. The labor cost per mile of line in open, level country with 500- to 700-ft. spans was as follows:

(*a*) Digging holes and placing foundations	$212.00
(*b*) Distributing material	77.60
(*c*) Bolting up and erecting poles	99.20
(*d*) Stringing wire	141.20
(*e*) Miscellaneous	44.80
Total	$574.80

These two examples probably represent maximum and minimum cost for jobs of this character. Cost data from any one job should not be applied indiscriminately to any other job unless all governing factors are identical in all respects. Of course, this condition never exists in practice; so the best M. P. can do is to study the above and similar data and apply them to his job.

Fort Worden, Wash. E. I. PEASE.

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Replacing Motors When Trouble Develops—When armature or other troubles develop in a motor, should a new armature be put in or other repairs made, right on the job? Or is it better to replace the entire motor with a spare and send the damaged motor to the repair shop? This question has come up several times in our plant and I should like to know the practice followed by other readers.

Pittsburgh, Pa. E. W. D.

Answering E. W. D. in the April issue, it is always better to take out the entire motor and put in a spare one, if a spare is available. However, unless there are a large number of duplicate motors in the plant, it would be a rather expensive proposition to keep an extra motor for every machine. Also, since a large proportion of the trouble on d. c. motors is in the armature, it is usually necessary to keep only a spare armature in stock. On the other hand, an outside repair shop always likes to have the whole machine, so that they can give the rewound armature a thorough testing out.

Peoria, Ill. GEORGE D. RINGNESS.

* * * *

E. W. D. asked an interesting question in the April issue. I would not advise sending an armature or complete motor to the repair shop for every little trouble that comes along. Many armature troubles, such as grounded V-rings, shorted coils, open circuits and the like can often be cleared up on the spot at a real saving in time and money.

For my part I do not believe it advisable to replace a motor so long as it can be kept running. If E. W. D. has many motors, he will find it worth while to have these little jobs taken care of whenever possible right on the job. M. V. MILLER.

Service Dept.,
Westinghouse Electric & Mfg. Co.,
Indianapolis, Ind.

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E. W. D., whose question appeared in the April issue, will find a very good answer in the form of an editorial on page 189 of that issue.

Outside of large installations or minor breakdowns, repairs should not be made in the field if they can possibly be avoided. If a motor or any piece of apparatus is so important that its service is absolutely necessary for the welfare of an industrial plant, continual operation is more easily insured by a spare unit than by any form of repair that can be made in the field, field shop, or service station. When a breakdown occurs less experienced men can, at less expense, replace the damaged job and leave the damage to be repaired by more intelligent personnel.

Furthermore, standardization of equipment means less overhead in maintaining good service, a point that many industrial firms overlook in purchasing equipment. I recall one firm that had the greatest variety of electrical equipment that I ever saw. There was available every kind of motor, control apparatus, transformer, and auxiliary that I ever saw in one place. You can imagine the subsequent upkeep cost in this establishment.

West Allis, Wis. EDWARD JAMES.

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Replying to E. W. D.'s question in the April issue, the general trend of practice at the present time is to change armatures or do what repair work is necessary in the field. With a little forethought and system this work can be done with very little loss of time.

However, it stands to reason that a first-class job of repairing cannot be made in the field, as in most cases time is limited and facilities may be lacking. Therefore, I believe that in the case of d. c. motors, especially crane motors, the ideal practice would be to change the entire motor. Then they could be taken to the shop and thoroughly overhauled, which cannot fail to result in increased efficiency and greater length of service.

In plants where the equipment is standardized, this procedure would be entirely practicable and still not involve a big financial outlay in duplicate motors.

Existing conditions are a big factor, of course, in determining just what should be done in this particular phase of industrial maintenance.

JOHN W. CUBBAGE.

Standard Tin Plate Co.,
Canonsburg, Pa.

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In answer to E. W. D.'s question in the April issue, I would like to state that it depends a great deal on how serious the repair is, on the service which the motor renders, its importance and its size, also, whether the repair shop belongs to the company or to a contractor. It is considered good practice in steel mills and foundries to keep spare motors for important machines, such as cranes and machinery handling hot metal. These spares are kept in the field, where the motor inspector can quickly substitute them for defective motors. In some cases, a whole crane is available as a spare. The reasons for this are obvious: the cost of the motor is insignificant compared with the value of a large ladle of metal or a cupola full of molten pig iron. Also, the labor cost of dropping bottom on a cupola is a large sum compared with the cost of an ordinary motor repair. Other reasons for having spare motors are that motors repaired in the shop are more perfect and reliable, because the shop men have more time and facilities for doing a more thorough job, and they are generally paid a higher salary and are expected to do better work than field repair men.

If the repair man is an expert judge of motor troubles, he can probably make a temporary repair on a motor that has a slight defect, and if a shutdown of an hour or so does not matter, he can put in new bearings, or cut out a coil in a motor of average size. Of course, the necessary repairs could be made under almost any condition and anywhere within reason if the necessary mechanics are available. If the repair shop belongs to the company and the motor is not too large it is probably the best practice to have complete spare motors for the more important drives. The transportation facilities available for taking motors to the repair shop will limit the size of motors that can be handled in the shop.

If a motor is large, say, 500 hp. or over, the cost of a complete spare motor would be prohibitive, even if the plant otherwise had to be shut down a day or so while repairs were being made. Also, in the case of large hoist motors at mines, it would be cheaper to shut down the mines for a week or so to rewind the motor. In this case, especially, the cost of transporting the motor and moving it into and out of the hoisting house would increase the repair cost. Also, as an illustration, take the case of a large pump motor several thousand feet inside of a mine. In this case, it would be cheaper to rewind the motor right on the job.

Acmar, Ala. GRADY H. EMERSON.

* * * *

Calculating Starting Resistance for D.C. Motors—Will someone please tell me how the amount of resistance that is used in the starting rheostats of shunt, compound and series d.c. motors is computed? (2) How are the different voltages obtained on the various taps of the compensators for a.c. motors and what are their usual values in percent of full-line voltage?

Albert, W. Va. F. H.

Answering the question asked by F. H. in a recent issue, the object of starting resistance is to limit the current through the motor armature during the period of starting; that is, until the armature attains a speed high enough to induce a counter-emf. sufficient to check an excessive flow of current. Ohm's law may be used to determine the amount of excess current in amperes that would flow before the armature began to turn, if there were

no starting resistance. Suppose for example that an armature has a resistance of 1 ohm and 110 volts are impressed on it; then by Ohm's law I=E÷R, or I=110÷1=110 amp.

If there were no starting resistance 110 amp. would flow through the motor armature just before it began to turn. Note that the above calculation applies specifically to shunt-wound motors. If the motor were series- or compound-wound, the resistance of the series field would also have to be considered.

To determine by Ohm's law the amount of starting resistance in the case of a series motor, assume that the nameplate current of the motor is 10 amp. As this is a series motor the current through both armature and field will be the same and the armature can safely carry away a current of 10 amp. Then R=110÷10=11 ohms, which is the total resistance required. To obtain the resistance required in the starting box, subtract from this total the series field resistance plus the armature resistance. Suppose these amount to 0.5 ohm plus 1 ohm or a total of 1.5 ohms. Then, 11 ohms—1.5 ohms=9.5 ohms, which is the required starting resistance.

In the case of a shunt motor the procedure is the same except that the current through the shunt field must be subtracted from the rated current in order to obtain the current through the armature and, of course, there is no series field resistance to be considered.

With a compound-wound motor, proceed as in the case of a shunt motor except that in order to obtain the starting resistance the resistance of the series field must be added to the armature resistance and the resistance of the two subtracted from the total resistance obtained by Ohm's law.

As the speed of the motor increases the counter-emf. tends to reduce or offset the applied voltage, so that less current will flow through the motor. Therefore, in order to allow sufficient current flow to produce the torque needed, the resistance must be reduced. Starting boxes are, therefore, made so that the amount of resistance in circuit can be reduced in a number of steps.

In the foregoing, the full-load current has been used in the formula, but it is a well-known fact that motors will carry a greater current for a short time, usually 125 per cent or more of the nameplate current rating, without injury. Because of this, if the motor must start under heavy load it may be necessary to allow 125 per cent or 150 per cent of the rated current to flow during the starting period, instead of the rated current.

A starting compensator is composed of one or more autotransformers. An autotransformer has but one winding which must serve for both primary and secondary windings. Any desired voltage up to the impressed voltage may be obtained by taking off taps at the proper point from the winding. Suppose, for example, that the supply voltage is 220 and we have a transformer coil of 144 turns with a 50 per cent tap taken off in the center. This 50 per cent tap includes one-half of the primary turns, or 144÷2=72 turns and the voltage across this tap will be one-half of the impressed voltage or 110 volts. The voltage across any tap is always the same percentage of the supply or primary voltage as the turns included by the taps are of the total primary turns.

Concord, Mass. DONALD FERGUSON.

* * * *

Answering F. H. in a recent issue, the method of calculating the resistance for starting direct-current motors is based entirely upon Ohm's law. It is common practice to limit the initial rush of current admitted to the motor to full-load value, and this determines the total resistance of the rheostat. This resistance can be easily determined by means of Ohm's law, R=E÷I, wherein *R* is the sum of the internal resistances of the motor and controller or rheostat, *E* is the line voltage and *I* is the full-load current of the motor. From this, it will be seen that the stand-still resistance of the motor from terminal to terminal plus that of the controller must be known or at least approximated in each particular case.

Having determined the total resistance required for starting and the frequency of starting, the designer is prepared to go further into details and decide upon the number of steps required and the proportion of the resistance in each step. The accompanying table gives the usual value for the resistance in each step and the per cent of full-load current which the resistance for each step should be able to carry continuously with a temperature rise not to exceed, say, 250 deg. C. This table is based on a current flow of 100 per cent of full-load amperes on the first step, for light intermittent starting duty, that is, one minute starting out of four.

The foregoing discussion deals only with the calculation of the resistance to be used and does not touch on the design of the resistance as regards heat dissipation. In a starting rheostat large quantities of heat are generated during the short period of starting, as the energy in the rheostat at that time is equivalent to the full, and often the overload, rating of the motor. In laying out the starting rheostat and in determining the size required it is helpful to calculate the total heat over a cycle of operations. A rheostat is assumed to be laid out according to the A. I. E. E. test specifications, or some other definite cycle, and the total heat generated during a given period can, therefore, be determined. If it is assumed that radiation is practically constant during the whole period of operation, the rate of radiation required to take care of all the heat generated can then be found and the size of resistor necessary determined approximately from a knowledge of continuous-capacity rheostats. For a short discussion of the calculations involved in the design of resistance starters, I would suggest that F. H. see paragraph 431, section 15, 4th edition of Standard Handbook for Electrical Engineers, or consult Pender's Handbook for Electrical Engineers, 1st edition, page 1369.

(2) Induction starters for polyphase motors are simply auto-transformers with a switching device for connecting the primary or stator winding first across reduced potential obtained from the starting transformer and then directly to the line. In large sizes these starters are usually arranged to operate in three or more steps, thus reducing the starting current surges. For medium-size motors they are generally designed to give one starting voltage

Per cent of total resistance and carrying capacity of each step of starting rheostat for d. c. motor.

Total Number of Steps		Percentages For Each Step								
		1	2	3	4	5	6	7	8	9
1	R	100								
	A	40								
2	R	80	20	R-Percent of total ohms						
	A	37	75	A-Percent of full-load amperes at continuous rating						
3	R	65	25	10						
	A	37	60	70						
4	R	49	27	15	9					
	A	37	53	59	64					
5	R	43	26	16	9	6				
	A	37	48	52	57	60				
6	R	38	25	16	10	7	4			
	A	37	47	50	53	57	59			
7	R	34	23	16	11	7	5	4		
	A	37	45	48	50	53	55	58		
8	R	31	22	15	11	8	6	4	3	
	A	37	44	46	48	50	53	55	57	
9	R	28	21	15	11	8	6	5	4	2
	A	37	42	43	45	48	50	52	54	56

ranging from 40 to 80 per cent of line potential; the motor is then thrown across the line. The starting voltage to be used will vary with the size of the motor, the resistance of its rotor, the starting torque required, etc.

Auto-transformers for starting induction motors are provided with taps permitting the choice of any one of several voltages. They are, however, designed for starting service only and are not intended to be left permanently in circuit. The taps usually provided give 50, 65 and 80 per cent of line voltage for starting; the 65 per cent tap is the one ordinarily used for average conditions.

Fort Worden, Wash. E. I. PEASE.

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Replying to F. H. in a recent issue, while the calculations as a whole are rather complicated, they are all based upon Ohm's law.

It may be said first that good, sound judgment must be used in every case, as the drives for different machines vary greatly and these variations must at all times be considered, especially in the case of large drives and on important machines with special characteristics.

For instance, a drive on a machine requiring constant torque and starting under full-load condition with probably an allowable maximum motor starting current of say 180 per cent of full-load current, cannot be considered in the same manner as a large fan which starts under no load, the load increasing with the speed of the motor. If F. H. will notice closely the catalogs of the various controller manufacturers, he will see that each starter or controller is adapted only for a certain kind of service and the apparatus is intended only for that service specified. Disregard of these precautions is usually accompanied by dissatisfaction with the apparatus and the manufacturer is blamed unjustly. In the past these complaints have been legion and the larger industrial plants today usually have a works engineer or industrial engineer who properly selects and applies apparatus of this nature.

Motor control and starting apparatus is usually divided into several classifications. A simple starter is a starter and nothing more. If used otherwise a burnout is usually the result. A controller is designed for the control of motors or other electrical devices requiring similar control. The types of equipment and methods of control are many. A good work on this particular subject is Fox's "Principles of Electric Motors and Control" published by McGraw-Hill Book Company, New York, N. Y. This book covers everything the average maintenance man can use on this subject and the principles are very clearly explained.

Assume that we wish to calculate the starting resistor for a 35-hp. shunt motor operating on 230 volts, 130 amp. full-load current. Assume that the resistance of the armature brushes, leads, etc., is 0.02 ohm. Since the maximum starting current is to be limited to 180 per cent of full-load current, 130 amp. $\times$180=234 amp. As the line voltage is 230 volts, then by Ohm's law 230 volts $\div$234 amp.=0.983 ohm. Since it will require 0.983 ohm to hold the maximum current inrush to 180 per cent of full-load value, it is evident that the resistance of the armature, leads, brushes, etc., is included in this total, as they are in series with the motor armature. The resistance of the armature was taken as 0.02 ohm. Then 0.983—0.02=0.963 ohm to be included in the starting resistor. This resistance will hold the maximum current rush down to about 234 amp. This inrush of current is only momentary, for the armature starts to revolve the instant the rheostat is moved to the starting position and as the speed of the motor increases the cutting of the flux of the shunt field by the armature conductors generates a back or counter-emf. in the motor, which opposes the line voltage and limits the current flowing from the line. The starting resistance permits only a safe current to flow when the armature is stationary, in order to protect the motor windings. When the rheostat is moved to the second position, another peak or inrush takes place and the armature further accelerates, allowing the line current to drop again to a safe value. This operation is repeated until the motor has accelerated to its full-load speed, at which time the counter-emf. holds the line current to its full-load value or at a value corresponding to the load placed upon the motor.

I have found the following table, which gives the per cent of the total resistance in the starter, for each step of a five-step starter, to be very useful:

1st step=30 per cent of total ohms.
2nd step=24 per cent of total ohms.
3rd step=19 per cent of total ohms.
4th step=15 per cent of total ohms.
5th step=12 per cent of total ohms.

Applying this table to the problem above, we would have:

1st step=0.963$\times$.30=0.2889 ohm.
2nd step=0.963$\times$.24=0.2311 ohm.
3rd step=0.963$\times$.19=0.1830 ohm.
5th step=0.963$\times$.15=0.1445 ohm.
5th step=0.963$\times$.12=0.1155 ohm.

It will be noticed that the resistance of the different steps varies, but the total always must remain the same for a given condition of load. Authorities differ on what constitutes the proper amount of the total ohms for each step, based upon their varied experiences. The results, however, generally are the same under average conditions.

The same starter can be used either on a shunt-wound or a compound-wound motor, under ordinary conditions, but where variable- or adjustable-speed motors are used and the larger part of the speed adjustments are made by a field rheostat changing the shunt field flux, somewhat different formulas must be used, taking into consideration these conditions.

For starting a series motor the ordinary type of starter is used, but as a series motor with a starter is rarely used except on hoists of the smaller type, and on cranes and other machines of like nature, a regulating resistor and controller are used. The formulas for the design of this type of resistor are more complicated.

Automatic controllers of the magnetic- and remote-control types are designed along similar lines for a given service, with the exception that less steps are required in the resistors for starters. Speed regulators, automatic control panels used for speed regulation of various machines, are designed with a certain number of steps, depending upon the amount of reduction required. The number of steps varies widely; on some machines three to five steps are considered sufficient. On others the complexity of the work requires even 10 or 15 steps, and on some of the large printing press controllers 18 or 20 steps are used.

In order to design a satisfactory controller, speed regulator or starter most of the factors have to be known and the available motor data must be furnished by the motor manufacturer. In addition, the designer has to consider other factors, such as the type of drive, the apparatus it is to be used on, the starting time the resistors are to be in actual service, starting torque, braking features and many others.

Chief Engineer, P. S. PENDER.
Metropolitan Engineering Co.,
Granite City, Ill.

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Answering F. H. in a late issue, one must remember that torque is expressed by the equation, $T=K\times\Phi\times i_a$, wherein T is torque, K is a factor which is constant for any particular machine, Φ is the main field flux and i_a is armature current.

If a motor is called upon to start a heavy load from rest, the starting torque may have to be as large, or even larger, than its normal full-load value. If the flux at starting has its normal value as provided by a shunt-wound field, then the starting current will, according to the equation, have to equal or perhaps be somewhat greater than the full-load value. But since the counter-emf. is zero when the armature is stationary, it is clear that at the moment of starting the armature current is limited only by the small armature resistance and incidental series field connections, if the motor is compounded "long shunt."

Evidently, the normal small running resistance of the armature must be increased at starting by inserting a rheostat in the armature circuit. As an example, a 10-hp., 220-volt, shunt-wound motor takes an armature current of approximately 40 amp. when carrying its rated load and has an armature resistance of 0.50 ohms. If full voltage were impressed directly upon the armature the initial current would be 440 amp., or more than ten times the normal full-load current. To limit the starting current to the full-load value, the resistance which must be put in series with the armature should be (220$\div$40)—0.5=5 ohms. The resistance of the starting rheostat is usually calculated to allow the initial current to be somewhat greater than that corresponding to full-load torque. This resistance is gradually reduced in a number of steps as the motor comes up to speed.

Starting compensators for starting induction motors are nothing more than an auto-transformer from which various voltages can be obtained by means of taps taken off at various points of the winding. A large proportion of general-purpose motors have about 50 per cent of normal line volt-

age impressed upon them when the compensator lever is in the starting position.

In the case of many large synchronous machines started by pole-face windings, the starting tap usually provides about 30 per cent of full line voltage.

CECIL H. GREEN.

Engineering Department,
General Electric Company,
Schenectady, N. Y.

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Why Does This Motor Run Slow?—We have two wound-rotor motors, each rated at 325 hp., 2,300 volts, 60 cycles, and 1,185 r.p.m. at full load. Both of these motors are running about 30 r.p.m below their rated speed. The frequency of the power supply is normal, for the generators are running at their correct speed of 3,600 r.p.m About nine years ago the ventilating fan blades were removed from the rotors of the motors and consequently during the summer the windings become quite hot. When the motors are running the pointer of the power factor meter swings continuously. The pumps that are driven by these motors have recently been overhauled, but there was no increase in the speed of the motor. Since the pumps are running at less than rated speed, the motors do not draw rated full-load current. Can some reader tell me what causes these motors to run at less than rated speed and how I should go about correcting the trouble?
Medicine Hat, Alta., Can. E. A. S.

In reply to E. A. S. in the May issue, I would say that his trouble lies in the rotors of the motors. My experience has been that where there is a drop in speed greater than that occasioned by the normal slip, the trouble has been in the rotor.

I am wondering if his controller goes to the full on position, shorting out the rotor, or whether it lacks one notch on the ratchet or star-wheel of going to the full on position, thus leaving one section of the grid resistance in the rotor circuit.

If the pumps are belt driven the flapping of the belt would tend to slow the motors down and cause heating.

Chief Electrician, EARL N. DILLARD.
Booth-Kelly Co.,
Springfield, Ore.

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In the May issue, E. A. S. inquires why two slip ring motors run 30 r.p.m. below the full-load speed as given on the motor name plates. There are so many variable factors affecting the slip of a motor that manufacturers can not make any guarantee in this regard. The more resistance that is inserted in the secondary circuit of the motors, the greater will be the slip. If the motors have been in operation over nine years it is quite likely that the brushes now used on the slip rings are of a different quality of carbon and if their resistance is greater than that of the original brushes, then it would tend to cause a decrease in speed. E. A. S. also states that the motors run hotter than originally, due to the removal of ventilating fans. This would tend to reduce the secondary current with consequent decrease in speed. Anything that E. A. S. can do to reduce the resistance of the secondary circuit of these motors will tend to reduce the slip and bring the speed up as near synchronous speed as practicable.

R. F. EMERSON.

Industrial Engineering Dept.,
General Electric Company,
Schenectady, N. Y.

Answering the question by E. A. S. in the May issue, I would like to offer the following suggestions which I trust may be helpful to him.

First, it is possible that the bearings may have worn sufficiently to allow the rotors to rub on the bore of the stators when the motors are running under load. In some cases of worn bearings feeler gages do not tell the whole story. This is particularly noticeable in certain types of windings having parallel groups. In any doubtful case it is advisable to take the rotor out and examine both it and the stator for bright spots. It is also possible that some of the parallel connections in either the rotor or stator have become open-circuited. However, inasmuch as the motors do not draw full-load current, the trouble would appear to be in the rotor. I believe it would also be a good idea to check the power supply over carefully for frequency, and so on to make sure that there are no irregularities.

Stratford, Ont., Can. FRANK HARLE.

* * * *

In reply to E. A. S. in the May issue, the performance of these motors is, I should say, good rather than poor.

Almost any good electrical book gives very good explanations of the action of an induction motor, and from these it can be seen that an a. c. motor, unless it be a synchronous motor, cannot run up to synchronous speed, as it depends on slip for the rotor currents that create torque.

These motors must be six pole, and as the frequency is 60 cycles, the synchronous speed is 1,200. Therefore, a total slip of 45 r.p.m., or 3.7 per cent, from synchronous speed is about as good as could be expected. It is possible also that there are loose or poor connections in the rotor, in the brush leads, brush contact, or some other part of the rotor circuits, because an excessive slip can be caused by high-resistance rotors, as is especially noticeable in the older types of a. c. induction motors, which have soldered or brazed end rings in the rotors.

These explanations may not be the correct ones in this case. A closer inspection and examination would be necessary to enable one to say positively just what the exact trouble is.

As to the power factor variation, it may be inequalities in suction or lift of the pumps causing temporary variations in motor currents which, if much less than three-fourths load would be rising in power factor with higher currents, and lowering in power factor with lower currents, because of the natural characteristic of rapid rise in power factor from 15 to 20 per cent to 70 or 80 per cent from no-load to about three-fourths load.

Boston, Mass. EDWARD A. GIBBS.

* * * *

Replying to E. A. S. in the May issue, this trouble must be either exterior to the motors or be something which affects both motors in exactly the same manner. It might possibly be due to reduced voltage at the motor terminals, as the torque of a motor is proportional to the square of the voltage, for any given slip. This will affect the speed somewhat. Also, inasmuch as these motors have been in service for quite a period of years, it is possible that the increased heating caused by the removal of the fan blades, together with the natural deterioration of the insulation and corrosion of terminals due to soldering, may be introducing a higher resistance in the secondary.

Errors can also be made by depending on the frequency meter, as these meters do not always give correct readings. As an example, I know of three frequency meters on one system reading, 59½, 60 and 60½, respectively. Erroneous results are sometimes obtained when checking speed with the tachometer. Only a short time ago I had an expensive tachometer read 732 r.p.m. on a checked speed of 727 r.p.m.

I would assume from your statement that the power factor meter may register in accordance with the pump cycle or pump characteristics. This point can be determined by noting the relationship which exists between the reading of the meter or the movement of the pointer and the pump cycle.

It is an easy matter to check insulation resistance to ground, and from phase to phase. As a matter of fact, it is not difficult to run a complete test on an induction motor, but I would suggest that the above-mentioned points be checked first.

West Allis, Wis. EDWARD JAMES.

* * * *

Replying to E. A. S. in the May issue, assuming that the frequency is definitely known to be 60 cycles I would suggest that the rotor be gone over very carefully and all connections at the ends of the rotor coils examined closely, as very often a connection may appear to be good and still have a good deal of the solder melted out causing a high-resistance joint. Several connections with poor joints will cause a motor to act very queerly. After the motor is up to speed, short-circuit the slip rings at the motor by putting a piece of heavy copper wire across the brush holder. After making sure that the rings are well shorted, take another reading of the r.p.m. and note if there is any increase in the speed. If there is an increase look over all connections at the controller and the grid resistance, as this is an indication that the controller is not short-circuiting the rotor properly on the last notch. If there is no increase in speed the trouble no doubt lies in the rotor.

I note that the speed of the motors at full load is 1,185 r.p.m. The synchronous speed would, of course, be 1,200 r.p.m. It appears, therefore, that these motors have very little slip for wound-rotor motors. Ordinarily a wound rotor motor has a slip considerably greater than a squirrel-cage motor. It seems to me that about 1,150 or 1,160 r.p.m. would be a good, full-load speed for a six-pole, 60-cycle, wound-rotor motor. Sometimes the nameplate data becomes disfigured and it is quite difficult to get the numbers correctly.

Electrical Engineer, WM. B. CONE.
Shevlin-Hixon Co.,
Bend, Ore.

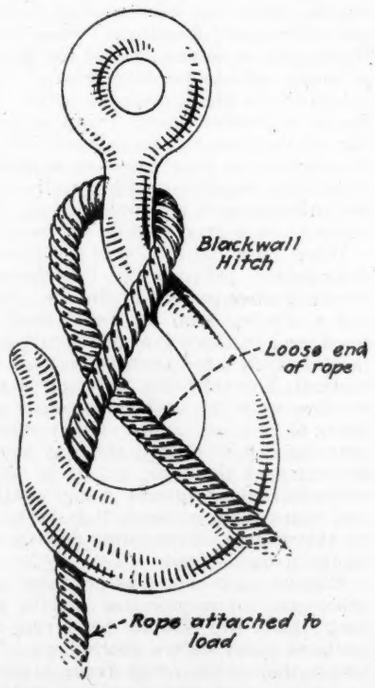
Building Maintenance and Plant Safety

The object of this department is to give details of building maintenance procedure and best practice in safety work. Articles on ways of handling natural wear and tear or other depreciation, repair methods, rebuilding, extensions, cleaning and painting operations will always be welcome.

How to Tie the "Cat's Paw" Hitch for Lifting Heavy Loads

FOR hoisting ordinary loads attached to a single rope, where a loop or sling is not used, the novice frequently has some difficulty in attaching the rope to the hook. For ordinary light loads, particularly where no danger is involved, the Blackwall hitch, shown in the smaller of the accompanying sketches, is frequently used. However, when heavier pieces are to be handled, the hitch known as the "Cat's Paw" is quickly made and easy to use, especially where short pulls must be made, and the blocks drawn up several times, as in the case of rope attached to a pole line or to a wire which is being pulled into a conduit when the overhead room is small. The method of making this hitch is clearly shown at (A) in the accompanying sketch. How it is applied to the hook is shown in (B). It is best to hold the loose end of the rope on each style of hitch at least until the load has pulled the hitch tight, to avoid the danger of it slipping.

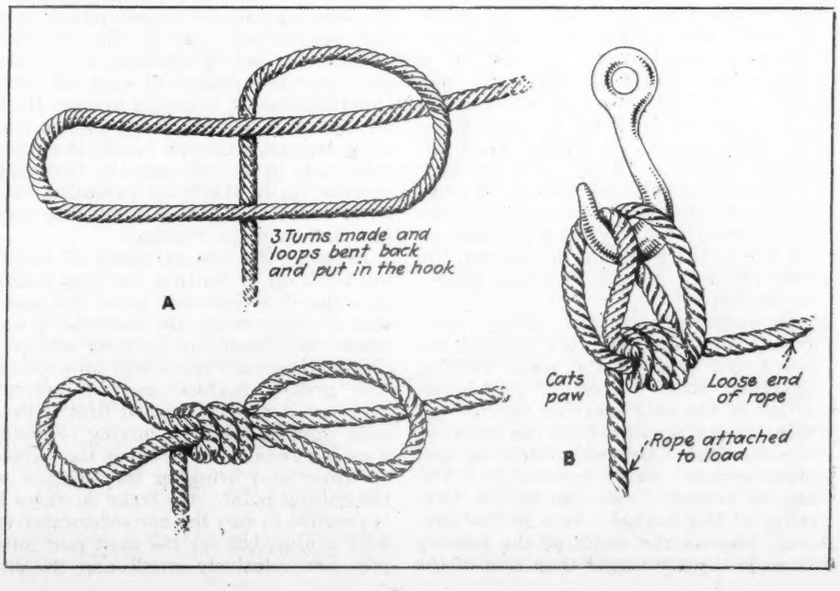
Oakland, Calif. S. H. SAMUELS.



This shows the method of tying the Blackwall hitch which is used for handling medium light loads. For heavier loads the Cat's Paw hitch, shown in an accompanying illustration, is generally more satisfactory.

These sketches show how the Cat's Paw hitch is made.

This is most commonly used where it is necessary to make several hitches in a rope to draw it up tight, as when pulling wire in a conduit and for other similar purposes. For heavy pulls it is more satisfactory than the Blackwall hitch, shown in the accompanying illustration.



Lineshaft Driven Fan Helps Keep the Shop Cool

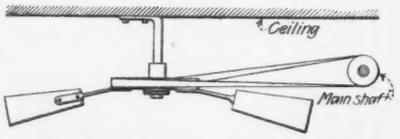
IN A machine shop and foundry that occupies a group of old buildings, the fan, shown in the illustration on the next page, is used successfully. Part of the machine shop is in a room which is pocketed, so far as air circulation is concerned, and has an unusually low ceiling. Two of these fans are installed there and the men report that they would rather work in this section in the warm weather than in any other.

The fans are simple affairs that cost about $5 each to put up and practically nothing to run. They are belted from a lineshaft that runs 120 r.p.m.; the fans run about 50 r.p.m., which is ample to keep up a circulation of air, but not enough to cause drafts nor stir up dust.

To make these fans a single piece of old bar stock was bent at right angles and screwed to the ceiling. It is threaded for a nut at the lower end and above that is an old thrust bear-

ing. A pulley salvaged from the foundry scrap heap comes next and to it are attached two arms of ½-in. steel, which are flattened out on the free ends so that the sheet-metal fan blades may be riveted on.

This outfit might be considered old-fashioned, alongside an electric fan,



This easily-constructed fan is driven directly from the lineshaft and keeps the air from stagnating in parts of the shop where the circulation is poor.

but it shows up well in first and operating costs and the results of an installation of this sort are very gratifying. If fans are installed in a shop with a low ceiling, some provision should be made to enclose the blades so as to prevent accidents.

Lubricating Kink Helps in Automatic Feeding of Material

PERHAPS two of the most important causes leading to diminished and inefficient production can be laid to frictional wear on machine parts, which requires frequent stoppage for replacement, and to difficulties experienced in obtaining smooth and continuous feed of material over frictional bearing surfaces. The obvious solution of these difficulties is lubrication.

For trimming the "burr" or "flash" from the bearing surface of large, hot-forged, track bolt nuts, the Buffalo Bolt Co., uses a series of electrically driven, semi-automatic, nut-burring machines. The design and operating characteristics of these machines are as follows: At one side of the machine is a large wooden box in which the untrimmed nuts are stored preparatory to trimming. A girl operator places the nuts face-up in a gravity feed chute. The untrimmed nuts slide down the chute by their own weight and feed automatically, one by one, in front of a pusher-arm which shoves each nut under a vertical revolving cutter head.

As each nut is placed in position by this pusher-arm, the cutter head descends, trims the "flash" from the face of the nut, and then returns to its original position. The trimmed nuts are then pushed ahead by those in back; as the end of the guideway is reached, the nuts fall into a steel container placed on the floor.

In operating the feed action, however, two difficulties were at first encountered, particularly when feeding hexagon nuts. First, the friction action of the nuts scraping against the sides of the runway wore the metal so rapidly that frequent shutdowns and replacements were necessary. The second difficulty was due to the jamming of the hexagon nuts in the runway, because the width of the runway is made slightly larger than that of the nuts in order to permit free feed of the material. During the feeding operation two opposite sides of each nut are parallel with the sides of the runway which brings a corner of each hexagon nut against a corresponding corner of the one in front and in back of it. Due to the combination of these two features, the natural tendency of the nuts, when being forced along by the action of the pusher-arm, is to turn, so that each nut tends to climb-up on the nut in front. When this occurs the feed action jams and stops.

Both of these difficulties have been overcome by a simple and inexpensive method, which consists of sprinkling a small quantity of cheap lubricating oil on the pile of untrimmed nuts in the wooden container. The oil quickly spreads over the surface of each nut and covers it with a film of lubricant. This lubricant in turn is imparted to the main chute, the horizontal runway, and the cutter tools as feeding proceeds. Thus the nuts themselves keep the feedways automatically lubricated at all times, and thereby has been eliminated all jamming of the material and frictional wear of the machine parts.

Buffalo Bolt Co., ARTHUR L. GREENE.
N. Tonawanda, N. Y.

Points to Consider When Painting Exposed Sheet-Metal Work

SOME painters believe that tin roofs should not be painted until after the tin has rusted; also some tinners have a theory that galvanized work ought not to be painted at all. There is a bit of truth in each. Because tin and galvanized iron are extensively used for roofs, gutters and leaders it behooves every executive of the maintenance department to know how to take care of them; otherwise they will become more expensive than copper products. The first thing to consider is that the so-called "tin" or tinned iron and galvanized iron are ferrous products and will rust, once dampness gets through the protective coating.

There is a greasy film on the surface of new tin and a residue from the zinc-coating process on galvanized iron. The reason that men in the building trades wait before painting is to give the elements a chance to wash off these superfluities. It is better to have them off, but Nature does not draw the line close enough, with the result that rust often sets in at once and the removing process really starts an oxidation that never ceases. A coat of paint over rust does not stop the rusting.

Between the two extremes of painting too soon or waiting too long before painting, it is better to paint too soon; that is, paint when the material is applied. No harm can be done and certainly some rust spots will be avoided. The greasy surface can be painted over; or it can be cleaned first with a soda solution made by mixing ordinary washing soda with 20 times its volume of water and bringing the solution to the boiling point. On large surfaces it is possible to run the hot soda water on with a hose, but for the most part such jobs are relatively small and the hot water can be brought to the job in pails. The solution is applied to the surface with brushes or rags, and it dries quickly without causing rusting.

In so far as the writer has seen, there is no objection to painting new tin as soon as put down. The priming coat of paint will contain linseed oil as a vehicle, and whatever grease or oil remains on the tin from its manufacture, or has been applied to protect it, will be present in relatively small amounts and will be absorbed by and mixed with the oil of the paint. Roof or bridge paint, or machine paint, well brushed on, is a safeguard that should be applied at once and doubts as to its efficacy forgotten.

Galvanized fittings should be painted as a preventive of maintenance expense. It is safe to allow rain to wash off the surface coating, but the painting should be done not later than a month after erection.

The popular expression, "Do it now," applies more truly to the painting of outside construction than to inside work, especially if maintenance is kept in mind. If galvanized construction is good "as is," it is far better and will last twice as long when properly painted.

It has been the writer's experience with outside maintenance that good, priming-coat machine paint is suitable for outside metal parts. In our plant Sherwin-Williams machine paint is kept in stock to be used on the product. To purchase the few gallons of other paint necessary to coat leaders seemed ridiculous when there was a metal paint on hand which would stick to castings. This led to the experiment on roofs. When mixed with pure linseed oil, this paint has been applied to gutters, elbows and flashings. When thoroughly dry, a second coat of the brown or green outside building trim is then put over the black machine paint. So far as the writer knows, every application of this paint is in splendid shape. A neighboring plant uses an asphaltic paint that is mixed with gasoline for the priming coat on roofs and it, too, seems to be a good outside protector.

When possible, it is best to do roof and gutter painting in the summer season during periods of drouth. Paint has a weaker grip on metal than on wood, and surfaces that are nearly horizontal wash more than those that are vertical. To avoid this, painting should be done at a time when there are not likely to be heavy rains. Other outside painting can be coaxed along at almost any time of the year, but it is worth while to replace gutters in dry weather and paint them at once; it is better to do this than to have paint flowing out of the ground spout.

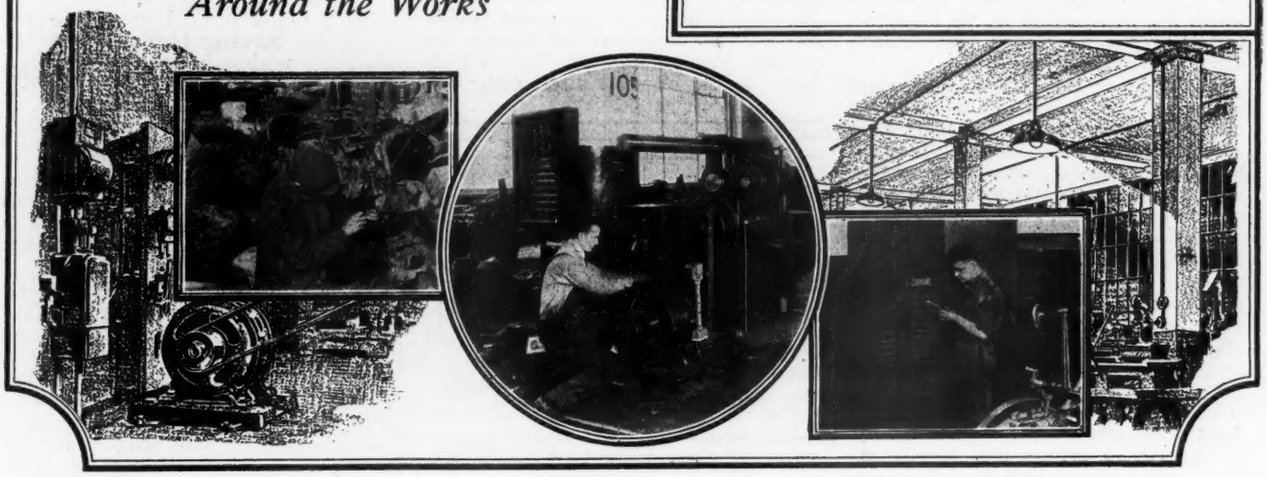
Elbows rust out faster than any other part of a pipe line and to prolong their life should be given two coats of paint before putting up. The elbow that takes away from a gutter can be painted and repainted without removing. It is worth the trouble, too, for it is usually the first part to rust out. This is due to the piling up of leaves and dirt which retain moisture.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Electrical Service

Around the Works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.



Method of Using Test Lamp on Grounded Circuits

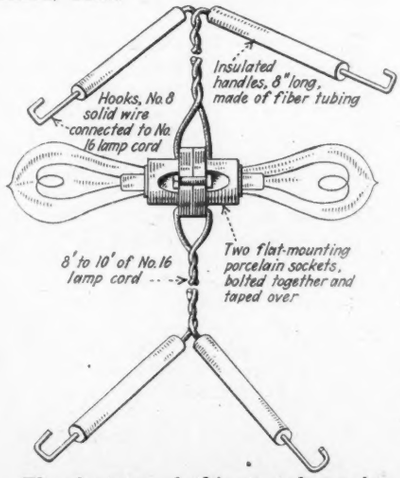
MANY electrical repairmen prefer a magneto and bell for testing motors for grounds and opens. This is a safe and convenient method, but hardly fills the need for testing motors, controllers and wiring where operating conditions involve service in the presence of moisture and chemicals. The magneto test is often deceiving under such conditions as in indicating a ground it does not discriminate between a solid and a high-resistance ground. The latter, however, is undesirable, and may come and go due to various conditions of moisture and temperature.

A very satisfactory testing device for general conditions is shown in the accompanying illustration. Two porcelain sockets are mounted back-to-back and bolted together. In each socket is placed a 50-watt, carbon or mill-type, 250-volt, lamp. This voltage of lamp will be satisfactory for use on 440-volt circuits. For 250-volt circuits, two 110-volt lamps may be used. The lamps are connected so that one lamp is in series with each test line. In other words, one lamp is in series with one of the test leads shown at the top of the illustration and with a corresponding bottom test lead. This prevents a flash or short-circuit to ground which might occur in case only one lamp were used in one test lead and no lamp in the other. In case only one lamp were used, a short-circuit might occur if the power supply used for testing became grounded, which is quite often the case, and one end of the test lead not having a lamp in series with it, were connected to the ungrounded side of the power supply and the other end of this same test lead connected to the grounded side of the device under test.

In order to prevent burning out a lamp due to a ground putting full line voltage on one lamp, a test should first be made from each line wire to the motor frame or the frame of any other device that may be under test. If no light is obtained from any line wire to the frame of the device under test, one side of each lamp, that is, either the top pair of test leads or the bottom pair of test leads in the illustration, is fastened to two of the line clips of the open motor switch. The other two test leads may then be used to test between the winding and frame or different parts of the windings, or to test fuses, compensators, and the like.

Quite often in case of grounds that are heavy enough to be serious, a small amount of smoke will be made during the test and the ground thereby located. The remainder of the winding will not be damaged. The resistance of the ground may be gaged by the brilliancy of the lamp, after some little experience.

J. ELMER HOUSLEY.
Electrical Engineer,
Aluminum Company of America,
Alcoa, Tenn.


Insulated handles, 8" long, made of fiber tubing
Hooks, No. 8 solid wire connected to No. 16 lamp cord
8' to 10' of No. 16 lamp cord
Two flat-mounting porcelain sockets, bolted together and taped over

The feature of this test lamp is that it affords safety to the user by having a lamp in series with each lead.

Either the top or bottom pair of test leads may be connected to the power supply. Then, when the other end of either test lead is connected to a ground and one side of the power supply is grounded, there will always be a lamp in series with the ground, thereby preventing a short-circuit that might injure the tester.

Trouble on Low-Voltage Trip Corrected by Time-Delay Relay

IN THE early days of electric power, interruptions to service were frequent and long. A slowing down and stopping of the motors warned the engineer that something was wrong. Through experience he learned that it was expedient to open the motor switch immediately when the service interruption occurred. If the motor switch were left closed when the service was restored the motor would be at a standstill and connected to full voltage, which caused many a burnout of the motor windings.

As the art of automatic protection developed, a low-voltage trip was installed on every motor switch. This consisted of an armature and a coil connected across the line voltage or across a potential transformer. The armature was mechanically connected to a device for opening the switch. When the line voltage dropped below a certain minimum, the coil would release the armature, causing the switch to open.

This protective device is at present installed on almost every motor switch. Only a few mechanical improvements have been made in the course of time. The device functions instantaneously and has served the purpose it was made for.

However, conditions have changed considerably since the time when this form of protection was devised. Modern power companies have only a few interruptions to service and most of these are extremely short. They are a mere flickering in the voltage; that is, a voltage dip, caused by some disturbance or switching on the power system. As the voltage during such a dip often drops lower than the holding voltage of the low-voltage coil, the low-voltage trip immediately opens the switch and shuts down the motor. This is unnecessary as the motor will stand for a short dip in voltage because the inertia

of the rotating parts will keep the motor in motion for a short period. Consequently this kind of protection now causes more trouble in the plant than it prevents. In paper mills, ice plants, sugar refineries and the like, there are a large number of motors which are so essential to the manufacturing process, that even a short shutdown will cause a loss.

The result of this is that many plant engineers have preferred to eliminate the low-voltage coil or block it mechanically. This again endangers the motor windings in case a service interruption lasts so long that the motors lose too much speed.

On the other hand power consumers are getting used to such good power service that they hold the power companies responsible for losses caused by power interruption. This attitude gives considerable concern to power companies. Some of these apparently felt guilty for some other reason and tried to improve conditions by changing the customers' protection devices.

However, I believe that this is entirely the wrong attitude. It is true that some power systems could be improved and some of the voltage dips eliminated, although it is impossible to eliminate them entirely. Line disturbances are mostly due to lightning and accidental short-circuits. It is unreasonable to charge a power company for not being able to do the impossible. The status is rather confused now because some power companies have given in and many have not taken a definite stand.

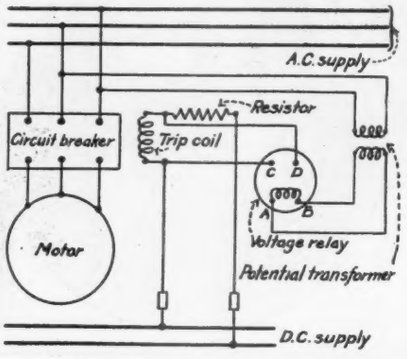
The solution lies in the use of a low-voltage trip attachment that does not function instantaneously but will hold on as long as the motor is running at such a speed that it can recover from the disturbance. A relay having a time delay will serve the purpose.

It is evident that the power consumer should pay for this improved protection. He did not object to paying for the instantaneous low-voltage trip. There is no reason why he should expect the power companies to pay for an improved protection.

To my knowledge there is at present no mechanical, time-delay low-voltage coil on the market. However, by using standard apparatus a time delay can be obtained, provided there is a convenient source of direct-current supply. This is possible with all synchronous motors, as the motor already depends upon direct-current for excitation, and this can be used for the tripping current. In the case of induction motors it is desirable to have a 12-volt battery. This will be objectionable for small installations, but in the case of large motors the additional battery cost is negligible.

The reason that a source of direct current is needed is so that there will be power to work the trip after the alternating-current supply has failed. If there were an alternating-current supply available that was absolutely independent of the supply for the motor, it could be used for operating the trip mechanism. To have two such power supplies would be very unusual, while having an independent direct-current supply would not be uncommon.

If a 110-volt direct-current supply is available, the original alternating-current, low-voltage coil can be used in most cases. A resistance is connected in series with this coil, which should be of such value that when coil plus resistance are connected across the 110-volt direct-current supply, the current flow through the coil will be equal to the original alternating current that flowed through the coil. A standard voltage relay having an inverse time element, such as a Westinghouse type CV relay, is connected across the line voltage or the secondary of the potential transformer in the same way as the low-voltage coil was connected previously. This connection is shown in the accompanying diagram.



A voltage relay having a time element prevents shutting down the motor in case of momentary dips.

The operating coil *AB* is connected across one phase of the alternating-current supply, as shown. In case the voltage dips below 60 per cent of normal the relay begins to operate. After a time interval, which may be adjusted to suit the individual requirements, the contacts *OD* are closed, thus shorting the trip coil on the circuit breaker and causing the oil switch to open.

The relay will start closing its contacts when the voltage falls under 60 per cent of the normal voltage. It is desirable to set the time element of the relay so as to close the contacts in one second when the voltage drops instantaneously to zero. These contacts will short-circuit the low-voltage coil and thus open the motor switch. This gives a time delay in the action of the trip, which will keep the motor on the line during momentary voltage dips.

The cost of this change consists of the cost of a resistance tube, of a standard relay, and of some wiring. This is usually liberally paid for if the arrangement eliminates one or two shutdowns.

Several plants have been equipped with this arrangement, and I have found that the results obtained are very favorable in each case. One plant had nine shutdowns during 1923. In January, 1924, the above arrangement was installed, which resulted in totally eliminating shutdowns during that year.

It is self-evident that this or any similar arrangement can only eliminate trouble due to voltage dips of short duration. It is impossible and inadvisable to keep a motor on the line if the power supply fails for longer intervals.

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Assistant Field Engineer,
Westinghouse Electric & Mfg. Co.,
New York City.

Saving Due to Care in Turning Out Mill Lights When Not Needed

THE importance of turning out electric lights when they are not needed, is frequently not realized. However, this is an example of a very large, needless expense which runs up the lighting costs markedly in a plant of any size.

In one of the large works investigated by the writer it was estimated that 35 per cent of the lamps of 400 watts and larger were left burning when not needed. The lighting load amounted to about 400 kw. After a little educational work by authority of the management only about 5 per cent of the lamps were left burning in the day time.

The saving was estimated at 1,440 kw.-hr. per day, which at the low cost of 1¼ cents per kw.-hr., amounts to $18 per day. In the course of a 300-day year this means a saving of $5,400.

D. W. BLAKESLEE.
Electrical Engineer,
Jones & Laughlin Steel Corp.,
Pittsburgh, Pa.

How Variations in Voltage and Frequency Affect Induction Motors

IN THE second edition, April, 1925, of The Electric Power Club's *Motor and Generator Handbook*, the following comments are made regarding the performance of induction motors when operated at voltages and frequencies other than those for which the motors were designed:

Induction motors are at times operated on circuits of different voltage or frequency from that for which the motors are rated. Under such conditions, the performance of the motor will vary from the standard rating. The following is a brief statement of some operating results caused by small variations of voltage and frequency, and is indicative of the general character of changes produced by such variations in operating conditions.

Voltage variations of 10 per cent on power circuits are allowed in most commission rules. However, changing the voltage applied to an induction motor has the effect of changing its proper rating as far as power factor and efficiency are concerned, in proportion to the square of the applied voltage. Thus a 5-hp. motor, operated at 10 per cent above the rated voltage, would have characteristics proper for a 6-hp. motor (6.05 hp., to be exact); and at 10 per cent below the rated voltage, those of a 4-hp. motor (more exactly 4.05 hp.). It is, of course, obvious that if the rating of a motor were greatly increased in this way, the safe heating would frequently be exceeded.

In a motor of normal characteristics, at full rated horsepower load, a 10 per cent increase of voltage above that given on the nameplate would usually result in a slight improvement in efficiency and a decided lowering in power factor. A 10 per cent decrease of voltage below that given on the nameplate would usually give a slight decrease of efficiency and an increase in power factor.

The starting and pull-out torques will be proportional to the square of the voltage applied. With a 10 per cent increase or decrease in voltage from that given on the nameplate, the heating at rated horsepower load will not exceed safe limits when operating in ambient temperatures of 40 deg. C. or less, although the usual guaranteed rise may be expected.

An increase of 10 per cent in voltage will result in a decrease of slip of about 17 per cent, while a reduction of 10 per cent will increase the slip about 21 per cent. Thus if the slip at rated voltage were 5 per cent, it would be increased to 6.05 per cent, if the voltage were reduced 10 per cent.

Higher than rated frequency usually improves the power factor, but decreases starting torque, and increases the speed, friction and windage. At lower than rated frequency, the speed is, of course, decreased; starting torque is increased; and power factor is slightly decreased. For certain kinds of motor load, such as in textile mills, close frequency regulation is essential.

If variations in both voltage and frequency occur simultaneously, the effects will be superimposed. Thus if the voltage be high and the frequency low, the starting torque will be very greatly increased, but the power factor will be decreased and the temperature rise increased with normal load.

The above facts apply particularly to general-purpose motors. They may not always be true in connection with special motors, built for a particular purpose, or as applied to very small motors.

An Example of What Plant Men Can Do to Help Speed Up Production

AN IMPORTANT part of the work of industrial men lies in providing many miscellaneous devices which facilitate plant operation and often production. This phase of the plant man's duties is well illustrated by the special car, shown in the accompanying illustration, which was constructed by the men in the *Electrical Department* of The Studebaker Corporation. Here it was necessary for a man to drive the automobile down an incline in taking it from one department to another and then to walk back up the incline to the starting point. To keep up with the output of cars demanded that the man walk about two and one-half to three miles a day up this 35 per cent incline at a fast pace. This was fatiguing and he would slow down on the work late in the day.

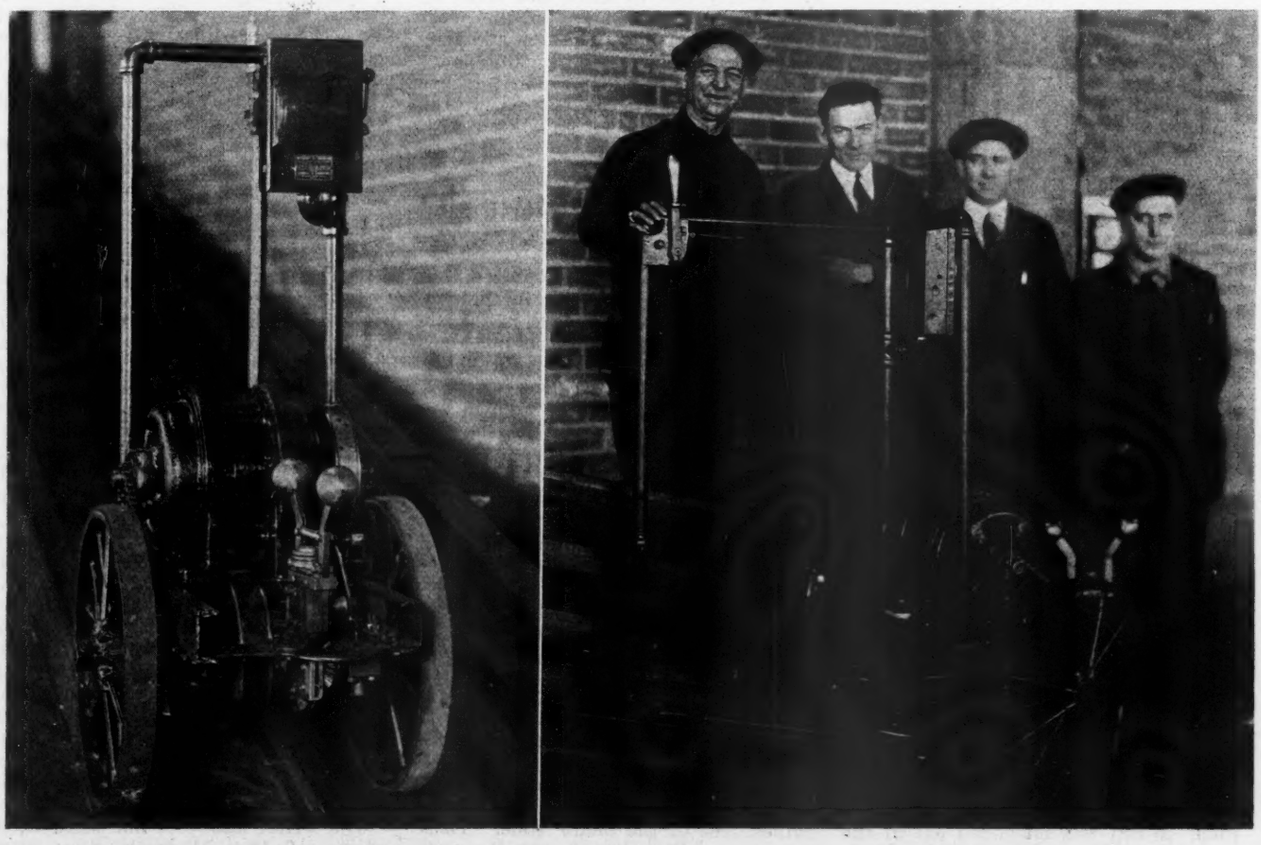
Finally, to relieve him of this uphill walk, the special car shown in the accompanying sketch was built. This is driven by an electric motor and controlled by the lever shown near the man's hand in the illustration at the right. The car is guided by an I-beam in the center of the track and is driven by the motor through chains and sprockets attached to the drive wheel. A fly-ball governor regulates the speed at which the empty car travels back down the incline by gravity. Current is transmitted to the motor through a brush contact on a trolley which is placed under an insulated beam close to the wall, as can be seen in the illustration at the left.

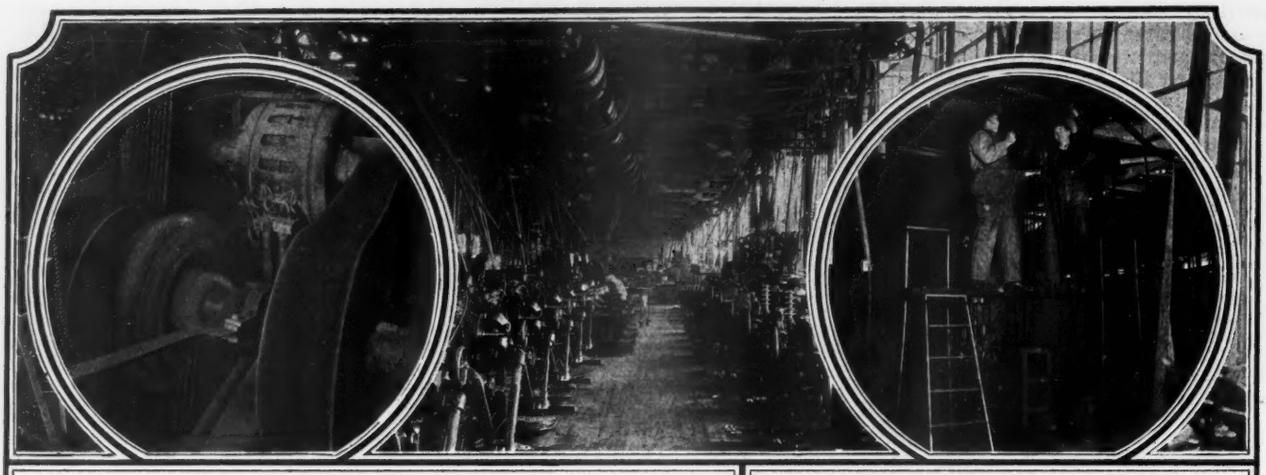
When the driver leaves the automobile at the foot of the incline, he steps onto the car, steadying himself by the handrails, and rides to the top of the incline. When he steps off the car, it automatically returns to the bottom of the incline by gravity. This car was constructed entirely from surplus, miscellaneous material.

The primary object of this equipment was to provide means which would not only make it easier for the man to get to the top of the incline, but also would speed up the operation, particularly toward the latter part of the day. This is only one example of the ingenuity which the typical plant man can apply in case of necessity.

This car was built by the men in the Electrical Department of The Studebaker Corporation, to perform a special task.

In transferring automobiles from one department to another, a driver takes them down an incline. To get back to the top quickly enough to handle the next automobile necessitated almost running up a 35 to 40 per cent incline. This car, driven by an electric motor, carries the driver up hill faster than he could walk and returns to the bottom of the incline under the control of a fly-ball governor, so that it is ready for him when he comes down again.





Mechanical Maintenance of

Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through transmitting equipment to all driven machines.

Bearing Renewals in Centrifugal Pump Made Easy by Adding Bearing Pedestal

ONE instance of where maintenance kinks have made a saving in operating expenses was in the case of a heavy-duty centrifugal pump, of old-fashioned design, that was on 24-hr. duty where a shutdown caused a considerable loss in production. This pump was driven by a steam turbine, direct-connected, with a 600-r.p.m., 150-hp. motor idling on the opposite side as a standby drive.

The bearings on the pump were attached to the pump cover, and were of a solid type which entailed the withdrawal of the shaft through the bushing in order to renew them. To do this, first the turbine had to be disconnected, the motor disconnected and pulled back, the couplings on the pump shaft removed and the end plates on the pump casing taken off. Not until all this had been done could the shaft and impeller be drawn back far enough to slip the bearing bushing off. It took 4 hr. to pull the pump down, and at least as long to put it together again.

The maintenance engineer wrote to the manufacturer of the pump about installing a split bearing on a separate pedestal where it could be gotten at without all this trouble. There was no redress from this quarter, however; the pump was made in that way and there the matter must rest, as far as they were concerned. The maintenance engineer thought differently and made a visit to the scrap heap, the happy hunting ground of maintenance workers. An old pedestal was dug up that did not need much work on it to make it into a serviceable bearing base. The problem of finding a 3½-in. split bearing block was not so easy; so one was burned out of an old crank disk that had been discarded. This was machined up and slotted to carry a split bearing shell. A cap was machined out of the same old disk and fitted to the block. When all was ready to install the pump was shut down.

This was done nearly a year ago and the bearing has not given a moment of trouble. New bearing bushings can be slipped in in 10 min. Also, it is possible to take them up from time to time, which was never possible before.

This work probably cost in the neighborhood of $100 for labor, a few dollars' worth of scrap and the cost of a 3-hr. shutdown of the pump under the old conditions. Results of this sort can hardly fail to show the value of maintenance work even to the most conservative of managements, and they emphasize the point that maintenance is a safeguard against repairs, rather than something to be classed in the same category. MAURICE COCKSHOTT.

Los Angeles, Calif.

How to Line Up a Motor Pinion With the Gear It Drives

A UNIVERSALLY recognized, but so far unheeded, lack in the construction of electric motors is the absence of lining faces, such as machined surfaces or pads, that are parallel to the armature shaft in one or more places and which could be used to line the motor correctly with the shaft it is to drive.

When the motor is first placed, the average method used to align it is to provide a reasonably level platform for it to rest upon. The motor is made parallel with the shaft by some such means as, laying out a right-angled line on said platform, measuring with a stick at two sides of the motor casing, or by placing a straightedge against the pulley or gear on the driven shaft and trying to bring the smaller pulley or pinion (on the motor) to bear against this at opposite points on its rim. In some cases a motor has a sub-base with planed top and bottom and planed ways on which the machined feet of the motor slide. These may be readily aligned, but the ordinary sub-base has nothing more than cored slots to guide the motor.

A silent-chain drive will work fairly well, if the centers are not less than recommended by the makers, even though there is some inaccuracy in the motor setting. Of course, the life of the chain is thereby decreased but it will continue to carry its load as long as it will last. A belt drive will do as well as the chain as long as the imperfect setting merely puts a twist in the belt. However, if the shafts are not parallel, the belt immediately climbs the pulley. The result is that the belt either slips off repeatedly or delivers only fractional power because only part of its width is on the pulley. Also, in the latter case, part of the belt receives all the wear.

The gear drive, even though out of alignment, will continue to operate as long as the teeth are in mesh. Partly for this reason and partly because these close-up settings are hard to check, the gear drive generally receives less attention than the other types of drives. Except where the individaul motor drive is arranged for in the builder's design, it is safe to predict that fully half of the existing drives in use would be found to be inaccurately set, if a careful check were made. Even on many supposedly correct drives, the motor has planed feet resting on flat surfaces which permit sufficient shifting to reduce by half the life of the gears.

Replacements of gear drives by chain generally originate in the desire for more quiet operation; however, the noise of properly cut and meshed gears on correctly aligned shafts should not be so great as to warrant the expense of changing for this reason alone. With noisy gears, generally much of the noise is due to the fact that the teeth are not correctly meshed and wear much more rapidly than do gears where the teeth carry equal loads and are perfectly aligned.

The writer knows of one installation where an 18-to-54 tooth, 3-in. pitch

drive was replaced every month for a year before the maintenance man told the owner that the gears wore from lack of alignment. The man who had put in the motor leveled up the timbers on which it was mounted and lined the shafts with a stick, which was all he had to work by. This was only an approximate setting to begin with and the timbers sagged in time, making things worse. Probably it would not have cost 50 cents to have machined some surfaces on the motor when it was built which could have been used to check alignment. If these had been there and used it would have saved the buyer $50 a month because the original installer could have had something finished to work by. Also other mechanics could have used them when gears were changed. The lack of such faces caused them all to dodge the task of checking alignment.

It is possible, by taking more time to the work, to line up motors with considerable accuracy. The tools required are one or all of the following: micrometers or calipers large enough to make an over-all measurement when the gears are in place, a level, a straightedge, a measuring rod, and metal feelers. Good lighting is also necessary.

How the caliper measurement is taken is shown in *A* in the accompanying drawing. It is essential in this that the gears be turned straight on their outside diameter. Measuring the gears at each edge will disclose any inaccuracy in setting, although with a narrow gear face this test becomes less valuable. The use of a micrometer caliper makes this a most significant test because any marked difference in the readings shows that the gears are meshed deeper on one side than the other and that only when the tooth shapes become worn will there be a bearing clear across. The same test may be made even more advantageously when the gears can be removed from their shafts, because the shafts are usually longer than the face of the gear, which permits a greater spacing between the measurements. Also, a reading which is made directly on the shafts avoids the inclusion of possible error in the turning of the gear blanks. This misalignment may be corrected by shifting of either motor or machine part until the reading is the same at both points, which indicates that the gears are set to an even depth.

Another test for the same alignment is made as shown by *B*. Here, a straightedge is held against one face of the pinion and the rim of the gear checked with this at opposite points for parallelism. This test is performed to best advantage when the gear can be moved on its shaft, carefully, to bring it within paper-feeler distance of the straightedge or within the thickness of metal feelers. To be of real value, the face of the pinion and the rim of the gear must be cut true with the bore and the fit upon the shafts must be close enough to avoid rocking.

The level is an instrument of precision, even in the hands of the unskilled. A piece of paper the thickness of this page placed under one end of a 6-in. level will move the bubble about 1/32 in., which is easily noted on a graduated tube. In *C*, the shafts of an overhead planer drive have had the gear and pinion removed for the level test and for an over-all measurement, by calipers as at *A*. A short level is better than a long one, when used on stub shafts such as these. When the center line between tne two shafts is roughly horizontal, one shaft that is not level will cause imperfect meshing, so that the teeth of the pinion will ride on one corner only and the teeth of the gear on the opposite corner.

Properly adjusted gears should have 0.002-in. clearance between teeth. A good test of this can be made with a 0.002-in. feeler or slip of newspaper, as shown at *D*. Such a test need be made at one side only and shows that the teeth are meshed to proper depth. An additional test for even setting across the face can be made with metal feelers or with a piece of wire filed in the lathe to a slight taper. This piece is inserted in the space marked *s* in *D*. If the taper piece goes in the same depth on each side, the shafts may be assumed to be parellel in that one plane. Feelers also show this.

By these methods, a motor can be lined with the driven shaft to a fair degree of commercial accuracy. The work is not open and direct, but requires care and patience because the measuring points are close together and some of the measurements require a nicety of feeling not generally associated with millwrighting. This work would be much easier done if spots were faced off on top of the motor, on each side, and a cut taken across the ends of the feet, which would provide known working points in two planes and at a good distance apart.

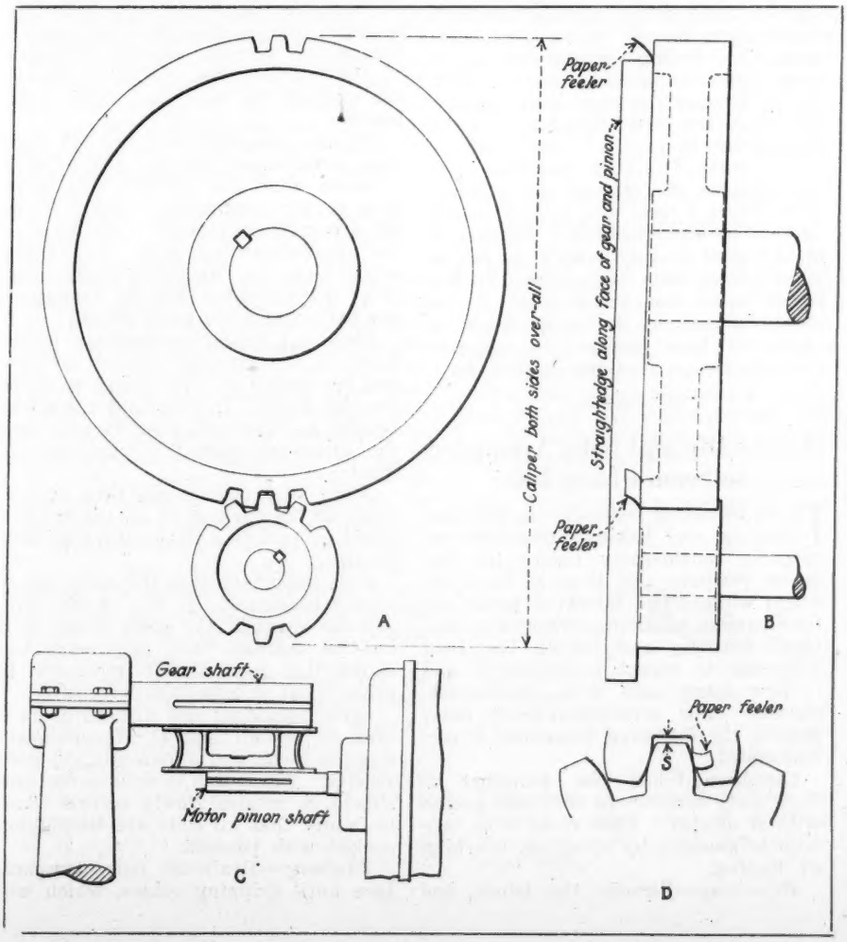
To secure the benefit of widely spaced measuring points, a measuring rod or tram can sometimes be employed to read between the driven shaft and the centers of the armature shaft. All motors are not open at the rear end, but some have a removable plate that will expose the center in that end. If properly done, this is a good check.

The large and unnecessary cost of pinion renewal is a big drag on upkeep funds. Many worn pinions are scrapped for so-called "noiseless" ones which also wear because they are not properly aligned.

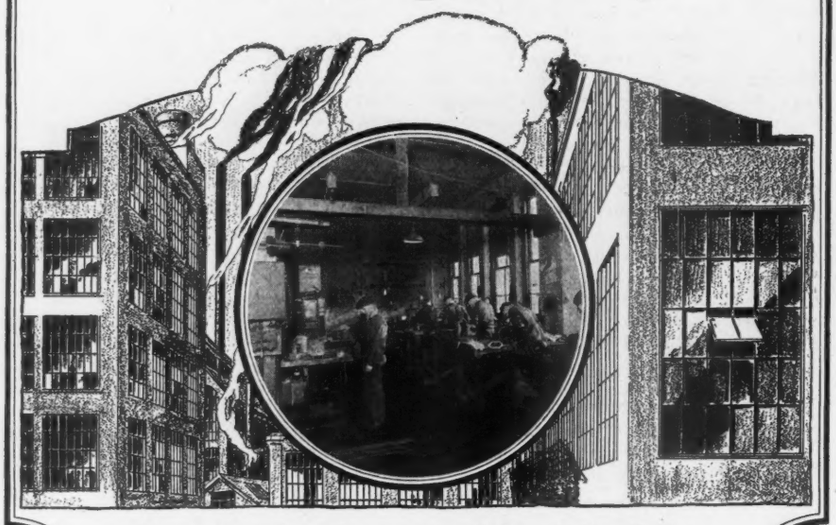
DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Four methods which may be used to check alignment of a gear and its driving pinion.

When gears and pinions are not aligned correctly they do not mesh properly, are noisy and wear rapidly. Where the face of the gear is wide enough, calipering the outside diameters, as at *A*, will show the correctness of the setting. If the sides of the gear and pinion are true and they can be slipped along the shaft a straightedge, *B*, can be used. Perhaps a still better method is to remove the gears and pinions and check the shafts with a level as at *C* and also with calipers as was done in *A*. Revolve the shafts 90 and 180 deg. and test with the level to see that they are not bent. Paper feelers, *D*, used as shown, and a metal feeler at *s*, are additional checks which can be relied on only when the teeth are true and not worn by previous misalignment.



In the Repair Shop



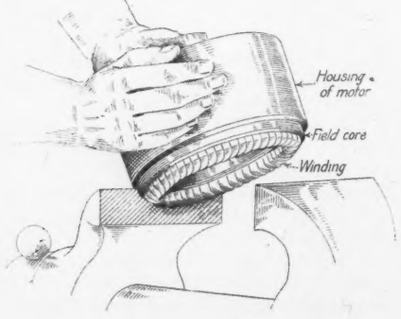
This section is devoted to repair work, large and small. Special attention is given to shop or bench tools and short cuts or improved methods. Contributions are always welcome.

How to Remove Field Cores from Fractional Horsepower Motors

THE article by G. H. Ennis on page 302 of the June issue on removing tight fan motor field cores, reminds me of the method I devised and use for this work. A standard vise is the only tool required to remove any style of core.

The field core of the motor usually projects out of the housing a distance of ⅛ in. or more so as to form a seat or joint for the removable end bell. The jaws of a vise are opened wide enough to permit the field core to pass, but not far enough to let the housing of the motor go through. Naturally all screws and bolts holding the core to the housing must be removed.

By bumping one edge of the housing on the jaw of the vice, as shown in the accompanying illustration, and turning the motor around slightly every few bumps, the field core will slide out of the shell. Only one side is bumped on the jaw at a time while the other is held on the other jaw to act as a hinge.



By resting one edge of the motor housing on one jaw of the vise and bumping the other edge of the housing against the other jaw, even a very tight field core may be easily forced out.

The jaws of the vise should be square, or sharp to prevent battering of the edge of the housing. I have never seen a core fail to come out by using this method, no matter how tightly it fitted in the housing. The edge of the housing may be battered slightly, but that is better than damaging the windings or the core as is usual when hammering on a punch placed through the vent holes against the end of the core. The burrs on the housing can be removed with a file.

This method seldom requires over five minutes to remove the tightest cores, which I have seen require nearly an hour by other methods. Further, it can be used on any kind of a fan or other fractional horsepower motor. Large cores can be removed in the same manner by bumping them on angle-iron bars fastened to supports.

Chicago, Ill. CARL G. HOWARD.

How to Dip and Bake Armatures to Secure Long Life

IT IS becoming generally agreed that dipping and baking armatures results in considerably longer life between rewinds and thus is decidedly worth while. The following procedure for cleaning, repairing, preheating, dipping, draining and baking has been subjected to recent investigation and is now being used with considerable success. For armatures being overhauled, the following procedure is recommended.

Cleaning—When the armature is very dirty remove the dirt and grease with a scraper. Then clean with benzine or gasoline by spraying, brushing or dipping.

Repairing—Remove the bands and insulation on the end windings and make necessary repairs. Make sure that the core bands are tight and that the coils are tight in the slots. If either are loose, reband, placing a filler in the slot when required to get pressure on the top of the coil; make sure that the bands are down on the iron.

When wedges are used, inspect them for tightness; if it is thought they will not tighten when dipped, it is best to rewedge, using fillers under the wedges to make the coils tight. Place temporary bands on the armature if there is a tendency for the coils to spring out of position while being dipped. Place the bands in such a manner that the armature will drain readily after dipping.

Some operators may wish to dip and bake their armatures without removing the bands or hoods. In such cases, care must be taken to see that the armatures drain and bake out satisfactorily. This is necessary to eliminate all trouble due to wet varnish inside of the armature.

Pre-Heating or Drying—Heat the armature in an oven having a free circulation of air, at a temperature of 98 to 105 deg. C. (208 to 221 deg. F) for the length of time indicated below: Armatures below 12 in. diam.—12 hr. Armatures 12 to 30 in. diam.—18 hr. Armatures over 30 in. diam.—24 hr.

Dipping—While the armature is still hot (approximately 50 deg. C.) dip in a good grade of baking insulating varnish. If it is dipped while too hot too much varnish will drain out. A black baking insulating varnish with a specific gravity of 0.840 is recommended, but other approved varnishes may be used, the specific gravity depending on the varnish and the thickness of the varnish coat desired. Should the varnish be too heavy, thin with benzine.

Dip the armature in a vertical position, commutator end up, and to such a depth that the varnish will come only to the commutator neck. Allow the armature to remain in the varnish for approximately 5 min. If a vapor arises from the varnish in large quantities this indicates that the armatures are too warm when being dipped.

Place all double-commutator armatures in a horizontal position so they can be rotated in the varnish to twice the slot depth. In case they cannot be rotated as described, pour varnish over the armature until the windings are filled.

After an armature has been dipped, wash off the varnish on all the finished metal parts with a cloth saturated with benzine.

It is important that the commutator be not immersed. If this should happen the varnish may work inside of it and be trapped, and experience has shown that it is almost impossible to drain it out or bake it satisfactorily.

Some operators roll armatures in a tank or trough instead of completely dipping them, and apparently get good results. When this is done armatures should be rotated slowly several times to insure that all coils are thoroughly soaked with varnish.

Draining—Drain at room temperature until dripping ceases, which will

require 15 to 20 min. Place the armature in such a position that there will be no pocketing of the varnish in the winding or the iron. When the armature is such as to require draining in other than a vertical position, turning will be necessary to avoid the gathering of varnish at one point. The amount of turning will depend upon the construction of the armature.

Baking—Bake the armature in an oven at a temperature of 105 to 115 deg. C, maximum at armature, until dry. This can best be determined by taking the insulation resistance with a megger. A constant reading for three separate tests indicates a dry armature. For most cases the length of time as given below will be sufficient to set the varnish thoroughly.

Armature below 12 in. diam.—48 hr.
Armature 12 to 30 in. diam.—60 hr.
Armature over 30 in. diam.—72 hr.

Bake the armature in such a position that there will be no pockets of the varnish when it is dry. In baking the armature in a vertical position, care must be taken in placing it in the oven so as to get a free passage of air through the air ducts and around the outside of the armature. Ventilation which provides a change of the air is necessary to secure the best results in baking.

When an armature is so constructed that the varnish tends to pocket when the armature is baked vertically, or in the case of dipping and baking with end bands and hoods in place, bake in a horizontal position. Such armatures are the old style ventilated ones with radial air ducts. Armatures baked in this position should be turned during the baking so as to avoid any gathering of the varnish at one side of the armature, which would tend to unbalance it mechanically. It is recommended that the hoods and bands of an occasional armature be removed after being dipped and baked and the winding inspected to determine whether or not the desired results are being obtained.

For armatures that have just been rewound, the following procedure should be observed:

Banding—After rewinding and soldering, place the armature in an oven for 8 to 10 hr. for heating before banding. If coils are high and it is thought that it will be difficult to get them down, and at the same time have tight bands, run on temporary bands. Use material enough under the bands so that the wire will not damage the winding. Place the bands so that there will be no tendency for the varnish to pocket during the dipping and baking.

If no temporary bands are needed, run the permanent bands on the core, but if the armature is baked in a vertical position, the hood and only the end bands that are up during the baking can be applied.

The armature is now ready for the dipping and baking and the procedure given above, beginning at *Dipping* should be followed.

In dipping and baking armatures the following precautions and hints will be found helpful:

If steam is used for heating, do not permit the steam to escape into the oven, thereby giving the apparatus a vapor bath. Do not permit the temperature to exceed 115 deg. C. at the armature.

Do not rush the baking period. A wet armature is worse than one that has not been treated.

Provide for the ventilation of the oven. Arrange for a complete change of air, eight or ten times an hour. Holes near the top and the bottom of the oven will usually provide a good natural ventilation.

Make sure that the temperature of the oven is uniform and maintained at the correct value.

Turn armatures frequently, if they are baked in a horizontal position, to prevent unbalancing.

Use an approved grade of black baking varnish.

Dip the armatures, keeping the commutator end up.

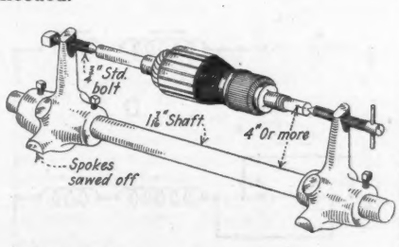
At one time it was recommended that armatures be baked at a temperature of 125 deg. C. from 24 to 48 hr. depending upon the size of the armature. This has been changed as it was found advisable to reduce the temperature from 125 deg. C. to 105-115 deg. C. maximum at armature, and to increase the time of 24 to 48 hr. to 48 to 72 hr. The reduced temperature at an increased baking time gives the best results, as the danger of taking the life out of the insulation is removed and the varnish bakes more evenly as the varnish on the surface of the armature does not set so rapidly. Experience and considerable experimental work confirms my opinion that the lower temperature should be used in order to obtain the most satisfactory results. The only advantage of the higher temperature is that the time of baking may be shortened thereby giving an increased production, and it is being used by some operators with apparently satisfactory results.

Wilkinsburg, Pa. A. C. ROE.

How to Make a Workstand for Small Armatures

OLD pulleys that had been through a fire were used in constructing this stand for small armatures. As can be seen from the accompanying diagram all except one of the spokes on each pulley were sawed off.

The pulleys are mounted on a short piece of shafting and fastened tightly to it by means of set screws. The shaft may be clamped in a vise to hold it in position, or it may be laid on a bench if so firm a mounting is not needed.



This stand is made from two old pulleys, a short piece of shafting, three set screws and two pointed stud bolts.

Through the upper ends of the two spokes a hole is drilled and tapped to receive the pointed bolts which act as centers to hold the armature.

This stand is heavy in construction and very useful for straightening small armature shafts. In this case the stand must be held in a vise and blocks laid on the vise as a fulcrum for a lever in applying force to straighten the shaft. After each attempt the armature may be tested on the centers to see if it is true.

Durant, Okla. J. P. KINCAID.

Method of Straightening and Cleaning Busbars

IN REVAMPING a switchboard installation for different conditions it was found that the rebuilding of the copper busbar structure could be most easily and safely accomplished by taking down the old buses, straightening out the bends and rebending them to fit the new conditions. No doubt, some of the bent busbars could have been used again by sawing off and splicing them to fit the new conditions, but after making a layout of the switchboard and trying to fit the old busbars to it, it was found that there would be too much loss of time for the slight benefit gained.

Accordingly, all of the busbars were sent to a coppersmith for straightening. The price for straightening these bars was 25 cents per bend, which we thought was quite reasonable. It was necessary for him to anneal the bend, then roll it as straight as possible, after which a careful peening was necessary to remove all traces of the old bend and to leave the busbars perfectly straight.

The original lacquer near the straightened bends on these busbars was discolored from the heat during the process of annealing. Several methods were tried to remove this discoloration. Paint removers were tried and found to be unsatisfactory. Neither alcohol nor ether was found satisfactory. Under this treatment, the old, discolored lacquer seemed to smear all over.

Sandpapering was then tried but found to be too tedious, as there were something like 275 bends that had to be cleaned. Sandblasting removed the lacquer and its discoloration all right, but the sandblast finish did not seem to appeal to the powers that be. Boiling in a caustic solution and dipping in acid gave very nearly the same finish to the copper busbars as did the sandblasting; so this process was also rejected.

We finally used a strip of fine sandpaper made endless and used on a modern sanding table, which is equally efficient for sandpapering wood or metal. This endless, sandpaper belt runs at a good speed and since a fine grade of sandpaper was used very little copper was removed with the lacquer by this process.

After cleaning all the bars in this manner, they were relacquered before being bent to fit the new layout.

Oakland, Cal. S. H. SAMUELS.

Installing Oil Circuit Breakers

(*Continued from page 379*)

freedom of throwing switches into full contact.

(5) Check adjustments on the horns of horn gap switches.
(6) See that all joints are secure.
(7) Check all clearances.
(8) Inspect all contacts for alignment.
(9) Inspect primary fusible cutouts with regard to contacts. See that the insulating tubes are in good condition and clean and that the fuses are of the proper ampere capacity.
(10) Inspect all contacts for alignment.

It is recommended that sufficient spare parts be carried in stock to enable the operators of switching equipment to promptly replace any worn, broken or damaged parts.

Better Industrial Illumination

(*Continued from page 365*)

truly the vast difference between lighting conditions such as are commonly prevalent, and lighting conditions that measure up to modern standards. These conditions are illustrated in a general way in Figs. 1 and 3. Our eyes function under such a wide variety of conditions that under poor lighting conditions we are seldom conscious of the fact that more light would increase the efficiency of our vision and produce a psychological effect which would make us mentally and physically more alert.

A large majority of the factories in this country are underlighted. They are losing an opportunity to increase production and to enjoy other benefits of better lighting, with the minimum of increase in overhead, because they do not give the proper attention to the lighting systems of their plants. Perhaps the rehabilitation of their existing lighting system would only involve the addition of a few lighting units, or merely a thorough cleaning of the equipment to bring it within reach of modern standards.

While most of our knowledge of what good lighting is and what it will do has been acquired in a comparatively few years, we have only begun to utilize the possibilities of light. Every year sees new developments and new standards which help us to secure profitably a wider and better use of light. In this rapid progress, old lighting methods and lighting equipment fall in the same category as machinery which is superseded by improved machines that reduce labor costs and speed up production. In view of these facts, the factory executive will do well to concern himself with the lighting of his plant, even though the existing installation may be only a few years old. Usually there is no hesitation in putting in a machine which will pay for itself within a reasonable time by virtue of the improvements that are incorporated in it. By the same token, improved lighting should not be treated with indifference when it will definitely pay for itself in dollars and cents through increased production, reduced accident hazards, and improved working conditions.

Other phases of this subject will be discussed in two articles which will appear in later issues.

Practical Pointers on Winding

(*Continued from page 383*)

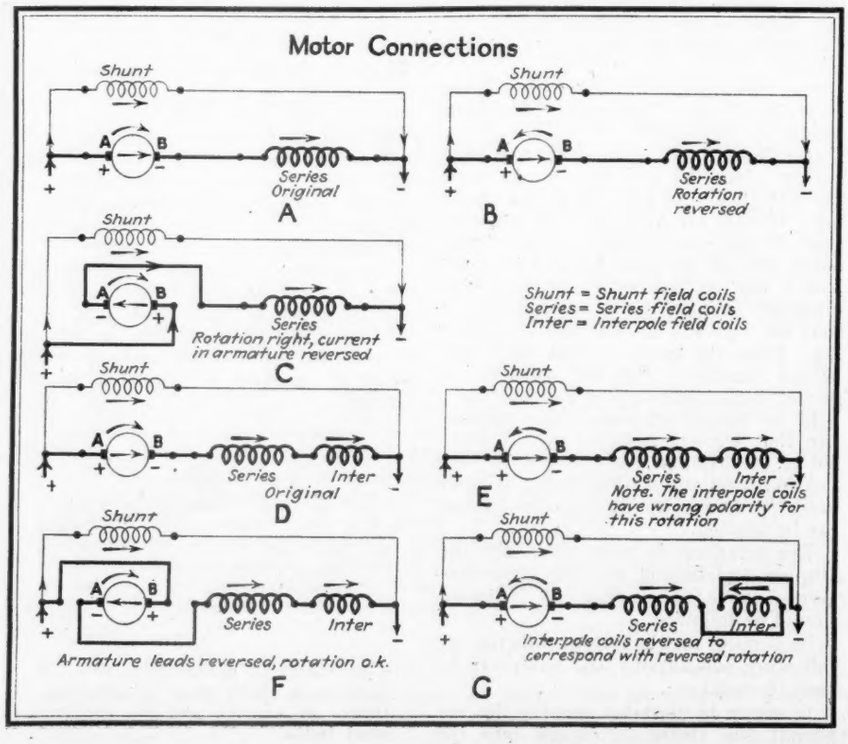
Fig. 6 *A* shows the standard setup for a compound-wound design. Note that with a motor we can show the current arrows for the series and shunt fields pointing in the same direction. In Fig. 6 *B* the armature winding has been changed, but the current arrows all point the same, the rotation having been reversed. Fig. 6 *C* shows the method of bringing the rotation back to standard by reversing the armature leads.

Figs. 6 *D* to 6 *G* show where it is possible to get into further trouble, when trying to correct a changed armature connection. Fig. 6 *D* shows a standard, compound-wound motor with interpoles. In Fig. 6 *E* the winding has been changed, resulting in a reversal of rotation. Now, if this rotation could be used, the polarity of the interpole coils would have to be reversed as shown in Fig. 6 *G*. This is explained by the following rule that applies to the polarity of interpoles in relation to the main coils and rotation:

In a generator an interpole will have the same polarity as the main coil ahead of it in the direction of rotation; it is immaterial which end of the machine we look at. In a motor the interpole ahead of any one main coil in the direction of rotation will have the same polarity as the main coil; therefore, if we change the direction of rotation, we must also change the polarity of the interpole coils. In Fig. 6 *F* the rotation has been brought back to standard by reversing the armature leads.

In the next article instructions will be given for taking data and also for marking the armature so as to insure its being rewound properly.

Fig. 6—These diagrams show correct and incorrect connections for compound-wound motors.



Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Ball Bearing Speed Reducer—Circulars announce a new spur-gear speed transformer, which has ball bearings throughout and in addition has special housings attached to the frame of the reducer which enclose the couplings attached to the shafts on each end.—Albaugh-Dover Mfg. Co., 2100 Marshall Blvd., Chicago, Ill.

Storage Battery Industrial Trucks and Tractors—Catalog 140 describes and illustrates the construction of the various types of tructors (electric storage battery tractors and industrial trucks) of the lifting and elevating platform types as well as the general utility or stationary platform type, tractors, crane trucks and other special equipment. In addition, a large number of illustrations show applications in many plants in various industries.—The Elwell-Parker Electric Co., Cleveland, Ohio.

Lubricating Devices and Oil Filters—A group of bulletins describes the Bowser oil filters, lubricators and pipe fittings for oil lines, and shows special applications of this equipment to lubrication and oil purification in industrial and other plants.—S. F. Bowser & Co., Fort Wayne, Ind.

Non-Corrosive Metal—Bulletin 1 gives a brief technical description of Alcumite, which is an acid-resisting non-corrosive metal, which is produced in the form of castings, sheets, rods or bars. This folder gives the physical characteristics as well as corrosion tests.—The Alcumite Corp., Division of the Duriron Co., Inc., Dayton, Ohio.

Natural Cooling of Transformers—Bulletin 101 describes the H.J.M. cooling unit, which consists primarily of an automotive, core-type radiator mounted horizontally in a sheet metal stack. The transformer oil to be cooled is pumped through the radiator and cools by virtue of the natural draft of air set up in the stack. This device is applicable to transformer installations of 2,000 kva. and up.—Hanson, Jones and Morey, 219 West Seventh St., Los Angeles, Calif.

Magnetic Testing Apparatus—Catalog 10 describes apparatus for capacitance and inductance measurements and for magnetic testing; 48 pages are devoted to a description of the various types of apparatus and their use.—Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

Laminated Bakelite—A folder describes briefly and illustrates a large number of the numerous products which may be made from Bakelite.—Bakelite Corporation, 247 Park Ave., New York City.

Quick Trip Graphic Meter—Bulletin 525 describes a special Esterline-Angus graphic meter in which, by means of a relay, any disturbance on the line changes the speed of the chart drive in 1/25 of a second from inches per hour to inches per second. When the disturbance ends, the relay resets the meter to the standard chart speed. This is to enable a careful study to be made of these disturbances.—The Esterline-Angus Co., Indianapolis, Ind.

Lubricators for Industrial Machinery—A bulletin with the above title, illustrates and describes a number of installations of McCord force-feed lubrication as applied in numerous industrial plants, such as on presses, forming machines, woodworking machines, glass bottle machines, toggle presses, rubber calenders and other equipment.—McCord Radiator & Mfg. Co., Lubricator Division, Detroit, Mich.

Panel and Benchboard Pipe Fittings—Bulletin 47703-C illustrates the different fittings and shows by sketches their applications, dimensions and specifications as well as the weight of each fitting listed in this 20-page booklet.—General Electric Co., Schenectady, N. Y.

Chain Blocks and Hoists—A booklet describes the self-lubricating, multiple-gear chain blocks which are built in sizes from ¼ to 20 tons' capacity, differential chain hoists, steel I-beam trolleys, the EverRedy electric hoist and double and single I-beam hand power traveling cranes.—Reading Chain & Block Corp., Reading, Pa.

Acid-Moisture Proof Propellor Fans—Bulletin 63 describes the Autovent propellor fans which are designed and constructed for use in places where surrounding hazards require the service of a fully-enclosed motor which will not be affected by acid fumes or moisture in the air.—Autovent Fan & Blower Co., 736-738 W. Monroe St., Chicago, Ill.

Direct Current Motors—Bulletin 141 describes the R. & M., constant-speed, d.c. motors from ¼ hp. at 870 r.p.m., to 20 hp. at 1,160 r.p.m inclusive. These motors are built in types S, C and I and are shunt and compound wound for standard voltages of 115, 230 and 32 volts.—The Robbins & Myers Co., Springfield, Ohio.

Automatic Arc Welding—Bulletin 48937.1, under the above title, gives a resume of the uses and value of arc welding, together with a description of the welding apparatus and generating equipment used. This bulletin is well illustrated by photographs of the equipment and applications.—General Electric Co., Schenectady, N. Y.

Pneumatic Tubes—Catalog 4 of the series, "Wherever Conveying Is Done," describes the equipment, arrangement and operation of pneumatic tubes, together with illustrations of a large number of installations of this equipment in industrial plants, in warehouses and for commercial work.—Standard Conveyor Co., No. St. Paul, Minn.

Bearings and Their Lubrication—A 40-page bulletin under the above title discusses this subject under the following headings: Bearing types, principles of the lubricating oil film, formation and maintenance of the lubricating oil film, characteristics of the lubricants, selection of lubricants, special examples of bearing lubrication, bearing trouble, and the benefits of correct lubrication. This bulletin is illustrated by drawings of different parts of mechanisms with the oil reservoir and path of the oil shown in color.—Vacuum Oil Co., 61 Broadway, New York City.

Paint Spray Troubles—A folder describes a special filter for use in paint spray booths to remove the paint before it enters the exhaust fan. These filters are placed between the operator and the exhaust fan and may be removed and cleaned when necessary.—Midwest Air Filters, Inc., 100 E. 45th St., New York City.

Welding and Cutting Apparatus—Catalog 172A lists, illustrates and describes the various Milburn cutting and welding torches, acetylene generators, preheaters and portable carbide lights, as well as other equipment.—The Alexander Milburn Co., Baltimore, Md.

Electrical Immersion Unit Heater.—Special electrical heating units of the embedded type, such as are used for the melting of Lavite and other salts which are used extensively for the tempering of tools, are described in recent literature. These units are placed inside of the pot containing the salt and are used to assist in bringing it to the high melting point. —Harold E. Trent, 259-261 North Lawrence St., Philadelphia, Pa.

Starting Switches for Small A.C. Motors—Bulletin 1048 describes the Type ZO starting switches for small alternating-current motors. These are push-button-operated, oil-immersed, across-the-line, induction motor starters which have no-voltage, overload and phase-failure protection.—The Electric Controller & Mfg. Co., Cleveland, Ohio.

Automatic Starters for Synchronous Motors—Bulletin 799 devotes 20 well-illustrated pages to a discussion of the principles of operation, explanation of diagrams, record of performance, protective features, source of actuating current, special features, rating, construction details and application of this type of apparatus.—Electric Machinery Mfg. Co., Minneapolis, Minn.

Synchronous Motors in Pulp and Paper Mills—Bulletin 875 devotes eight pages to such use of synchronous motors, describes their construction and operation and lists a number of applications.—Electric Machinery Mfg. Co., Minneapolis, Minn.

Boxes, Baskets and Trucks—A special catalog describes a lightweight box or basket constructed of smooth elm wood slats woven together with strands of wire for the sides for

handling material in the shop or warehouse. These boxes are reinforced at the edges with heavier wooden strips and at the corners with metal. Casters may be added for trucking. The boxes are constructed so that they may be repaired if necessary.—D. B. Lewis Co., Watertown, Wis.

Electric Drill—A series of folders describes the four different sizes of Super Hole Shooter which are made to take drills up to ¼ in., 5/16 in., ½ in. and ⅝ in. This has a universal-type motor which may be furnished for either 110, 220 or 32 volts as specified. It will operate on 25-, 40- or 60-cycle alternating current. This drill also automatically blows the chips away. The folders give other advantages claimed for this equipment and also list a number of accessories, such as emery and polishing wheels, drill stands and so on. These four sizes of drill are designed to operate at speeds of 1,800, 1,400, 600 and 450 r.p.m., respectively.—Milwaukee Electric Tool Corp., Milwaukee, Wis.

Switchboards, Panel Boards and Special Electrical Apparatus—A catalog describes some of the various lines of special products manufactured by this company, such as Shockpruf panel and switchboards, relays, remote control switches, watertight floor receptacles, power wall receptacles, special equipment for alarm systems and other electrical specialties.—Butte Electric & Mfg. Co., 956 Folsom St., San Francisco, Calif.

The Dragon—A monthly house organ which is published under the above name in the interests of the Fafnir Ball Bearing Co., describes in an interesting way some of the installations of Fafnir bearings. The May issue describes the ball bearing mountings in a motor and in a woodworking machine application.—The Fafnir Ball Bearing Co., New Britain, Conn.

Arc Welder—A folder describes the Hansen arc welding generator which needs no stabilizing device to assist the operator to strike and maintain the arc. A description is also given of the Hansen-Oesterlein process of welding squirrel-cage rotors.—Northwestern Mfg. Co., Milwaukee, Wis.

How to Select Good Lubricants—A 52-page booklet under the above title is offered as an aid to the purchaser of lubricating oils and greases in choosing the grades that will help toward developing maximum efficiency in power equipment.—Dearborn Chemical Co., 310 So. Michigan Ave., Chicago, Ill.

Portable Electric Sander—A circular describes the Barker portable electric sander and grinder which uses sand paper or emery cloth on a wheel revolving at 4,000 r.p.m for finishing flat surfaces, or for removing varnish or paint from old surfaces before refinishing. This sander is operated by a 1/3 hp. motor.—R. L. Barker & Co., 642 W. Washington Blvd., Chicago.

Arc-Welded Building—Folder 4657 describes tests made of welded joints, the results of which led to the erection of a 40-ft. by 60-ft., one-story steel building from steel salvaged from the scrap pile. An interesting comparison is made in this folder of the erection cost of arc-welded buildings with that of riveted buildings.—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Rubber Tile for Floor—A folder describes the Wright rubber tile and gives directions for laying it. This is used for special floors and for stair treads.—Wright Rubber Products Co., Racine, Wis.

Tumbler Type Motor Starting Switches—A small folder describes this equipment for use on fractional horsepower motors and heavy lighting circuits.—Trumbull Electric Mfg. Co., Plainville, Conn.

Fractional Horsepower Repulsion-Induction Motors—A circular describes the Type RF repulsion-induction motors with ratings of 1/6, ¼ and ½ hp. These are made for 60-, 50-, 40- or 25-cycle operation.—The Robbins & Myers Co., Springfield, Ohio.

Convertible Power Panel—A folder describes the Square D convertible power panel which provides a simple and easy means for adjusting at any time the spacing of the fuse jaws to provide for 30-, 60- or 100-amp. fuses, as may be required by changing conditions. The new voltage tester which requires no lamp is also illustrated in this folder.—Square D Co., Detroit, Mich.

Vacuum Cleaner for Industrial Plants—Bulletin 1030 describes the portable No. 5 double utility vacuum cleaner, which may also be operated as a blower, and its use in industrial plants for cleaning machinery by either suction or blowing. This cleaner is mounted on three wheels and transported by a handle like a truck.—The B. F. Sturtevant Co., Hyde Park, Boston, Mass.

Electric Hoists for the Iron and Steel Industry—The 40-page Bulletin 80 describes the use of Shepard electric hoists, illustrates the different types of equipment, and shows some of the many applications possible in the iron and steel industry. In addition to the trolley, cage-operated, crane trolley, monorail hoists, and several special hoist applications, back-geared motors and speed reducers as well as industrial winches are included.—Shepard Electric Crane & Hoist Co., 415 Schuyler Ave., Montour Falls, N. Y.

Ventilating Apparatus—A pocket-size catalog, 11th edition, discusses Autovent propeller fans and blowers for ventilation.—Autovent Fan & Blower Co., 730-738 West Monroe St., Chicago, Ill.

Glue and Solder Pots—A folder discusses and describes automatic electric glue pots of 2-, 4- and 8-quart capacities, which automatically maintain a temperature between very narrow limits, and solder pots of 15 or 30 lb. capacity, which are made for operation on alternating or for direct current and automatically keep solder, babbitt, white metal or wax at a predetermined temperature.—Automatic Electric Heater Co., Warren, Pa.

Automatic Start Motors—Announcement is made of a new automatic self-starting, ball-bearing motor with no moving parts in the starting mechanism. This is a simple squirrel-cage motor with an improvised squirrel-cage rotor so designed that when the current is first thrown on it is carried in part of the cage until the motor attains its speed. At this point through magnetic or inductive action the complete squirrel-cage takes the load. These motors are made in ratings from 1 to 50 hp. inclusive.—U. S. Electrical Mfg. Co., 200 E. Slauson Ave., Los Angeles, Calif.

Extension Reel—A folder describes the Reelite and its uses with drop cords, on machine tools and for other purposes.—Appleton Electric Co., 1718 Wellington Ave., Chicago, Ill.

Solderless Connectors—Catalog 20 gives price list, code words, dimensions and other useful information about the Dossert solderless connector for standard and solid wires, rods and tubes.—Dossert & Co., 242 W. 41st St., New York City.

Gears—Catalog 46 gives directions for ordering gears, with lists and prices of various gears, pinions, pinion rods, herringbone, internal, miter, spiral, worm and bevel gears, sprockets and silent chains and the Boston speed reduction units, which consist of herringbone or worm reduction gear sets.—Boston Gear Works Sales Co., Norfolk Downs, Quincy, Mass.

Collar Oiling Bearing—Bulletin 112 describes the Cleveland type collar-oiling bearing, which is a positive oil feed distributing system. Instead of using a loose ring or chain for conveying the oil to the journal, a fixed collar is employed, which provides a positive means of elevating the oil from the reservoir in the bottom of the bearing. The bulletin also contains descriptions of hangers and pillow-blocks.—The Hill Clutch Co., Cleveland, Ohio.

Double-Worm Speed Reducer—Recent announcement is made of a new type of speed reducer in which two worm gears are used to give high reduction ratios, such as are required on conveyors and other similar equipment.—Foote Bros. Gear & Machine Co., 236-246 North Curtis St., Chicago, Ill.

Supports for Overhead Equipment—A folder describes the Midwest steel stringers and box rails which may be installed in buildings with reinforced concrete or mill-constructed ceilings, or attached to I-beams. With these attachments lineshafts, motors and other equipment may be attached to the ceiling easily and economically.—Midwest Steel & Supply Co., Inc., 100 E. 45th St., New York City.

Saving from 40 to 60 Per Cent of Handling Cost—A 36-page illustrated booklet under the above title describes the Cowan system of materials handling and shows by examples taken from a number of plants the savings which have actually been made in particular installations.—Cowan Truck Co., Holyoke, Mass.

Roller Hanger Bearings—A 24-page booklet entitled, "Facts About the Dodge-Timken Roller Hanger Bearing," gives a short account of the history of the Dodge Mfg. Co., and The Timken Roller Bearing Co., with a description of the Dodge-Timken roller hanger bearings and how they are made.—Dodge Mfg. Co., Mishawaka, Ind.